4981

GAS

FORMERLY WESTERN GAS

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Reflecting Quality

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PITTSBURGH EQUITABLE METER CO.

MERCO NORDSTROM VALVE CO.

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AUGUST 1936 ♦ ♦ 25 CENTS

When a material serves as long and satisfactorily as cast iron pipe has in gas distribution service, opportunity for improvement is limited. Yet performance records and A.G.A. Laboratory tests prove that stuffing-box type mechanical joints, as made by C.I.P.R.A. members, represent a major improvement.

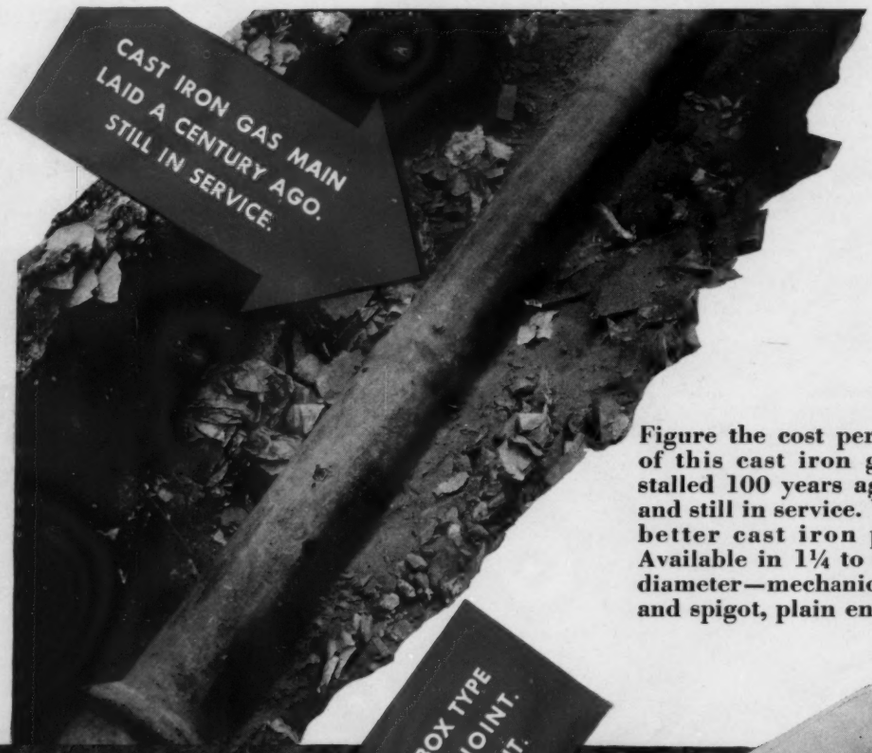

Figure the cost per service-year of this cast iron gas main installed 100 years ago in Boston and still in service. Yet we make better cast iron pipe today. Available in 1¼ to 84 inches in diameter—mechanical joint, bell and spigot, plain end or flanged.

CAST IRON PIPE

THE STANDARD MATERIAL FOR DISTRIBUTION MAINS

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ADVERTISERS' INDEX

The American Brass Company	59
American Gas Products Corporation	57
American Meter Company	12
American Stove Company	75
Art Concrete Works	102
The Barber Gas Burner Co.	109
Barber-Greene Company	—
Barton Brown Engineering Corp.	98
The Barrett Company	3
H. R. Basford Company	91
Blaw-Knox Company	113
The Bristol Company	7
The Cast Iron Pipe Research Association	2nd Cover
The Chaplin-Fulton Manufacturing Co.	108
Coast Counties Gas and Electric Company	110
Connelly Iron Sponge & Governor Company	102
The Cooper-Bessemer Corporation	8
Cribben & Sexton Company	—
Dearborn Chemical Company	110
Detroit Michigan Stove Company	85
Domestic Manufacturing Company	94
S. R. Dresser Manufacturing Company	1
Ducommun Metals & Supply Co.	95
Electrogas Furnace & Manufacturing Co.	96
Electrolux Refrigerator Sales, Inc.	—
The Estate Stove Company	61
Fairmount Hotel	104
Fluor Corporation, Ltd.	103
Forster Manufacturing Company, Ltd.	107
Fraser Furnace Company	91
General Ceramics Company	106
General Gas Light Company	63, 107
Glo-Fire Sales Company	114
James Graham Manufacturing Co.	55
Greenlee Tool Company	111
Grove Regulator Company	4
Handbook Butane-Propane Gases, 2nd Edition	99
The Hotstream Heater Company	—
Inland Manufacturing Company	110
Johns-Manville	71
Johnson Gas Appliance Company	111
Kerotest Manufacturing Company	98
Los Angeles Gas and Electric Corp.	93
Merco Nordstrom Valve Company	81, 82
Milwaukee Gas Specialty Co.	79
Minneapolis-Honeywell Regulator Co.	65
Mueller Company	104
L. J. Mueller Furnace Company	10
The National-Superior Co.	5
National Tube Company	—
Natural Gas Equipment, Inc.	105
Pacific Coast Gas Association, Inc.	100
Pacific Gas and Electric Company	72, 73
Pacific Gas Radiator Company	113
Payne Furnace & Supply Co.	77
Pittsburgh Equitable Meter Company	Front Cover
Porcelain Enamel Institute, Inc.	105
Pressed Steel Tank Company	99
Reliance Regulator Corporation	9
Republic Steel Corporation	6
Reynolds Gas Regulator Co.	109
Robertshaw Thermostat Company	96
Geo. D. Roper Corporation	—
San Diego Consolidated Gas & Electric Company	89
Safety Gas Main Stopper Co.	106
M. B. Skinner Company	11
Southern California Gas Company	93
Southern Counties Gas Company	93
Spencer Thermostat Company	69
The Sprague Meter Company	Back Cover
United States Pipe and Foundry Co.	3rd Cover
United States Steel Corporation	—
Ward Heater Company, Ltd.	66, 67
Watrola Corporation, Ltd.	112
Welsbach Company	87
Worthington Pump and Machinery Corporation	—

GAS

FORMERLY WESTERN GAS

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Contents for August, 1936

(Annual Technical Edition)

GUEST EDITORIAL: "Gas Marches On"..... *By H. M. Crawford* 13

43rd Convention Program, Pacific Coast Gas Association..... 14

GAS Camera Goes to Vancouver..... 18

PACIFIC COAST GAS ASSOCIATION TECHNICAL SECTION:

Resistance of Pilot Lights to Air Currents..... 19
By C. Eldon White and C. W. Stewart

Equipment and Methods for Gas Service Training..... 22
By J. E. C. Currens and C. P. Perkins

Thermostats for Gas Space Heaters.....Report: *T. G. Wallace, Chairman* 26

Leaks on High Pressure Natural Gas Transmission Mains—Their Causes, Prevention, and Methods of Repair.....*By Fred E. Wilson* 31

Clearance Pockets for Transmission Line Compressors.....*By Harry J. Smith* 36

Gas Dehydration by Calcium Chloride Brine Method.....*By W. K. Dodd* 41

Locating Accidental Contacts on Cathodically Protected Pipe Lines..... 43
By H. J. Keeling

The Internal Corrosion of Natural Gas Transmission Pipe Lines..... 46
By M. T. Burton

Current Practice and Trends in Orifice Metering..... 51
Report: *E. H. Fisher, Chairman*

Application of the Reynolds and Expansion Factors in Gas Measurement..... 51
By E. H. Fisher

Effects of Air Density on Measurement of Specific Gravity of Gas..... 53
By R. P. Work

Gas Calorimetry.....Report: *Guy Corfield, Chairman* 58

BUTANE-PROPANE NEWS 97

Butane Trap Wagon Trailer Units..... 97

Canadian and West Coast Session at Vancouver..... 101

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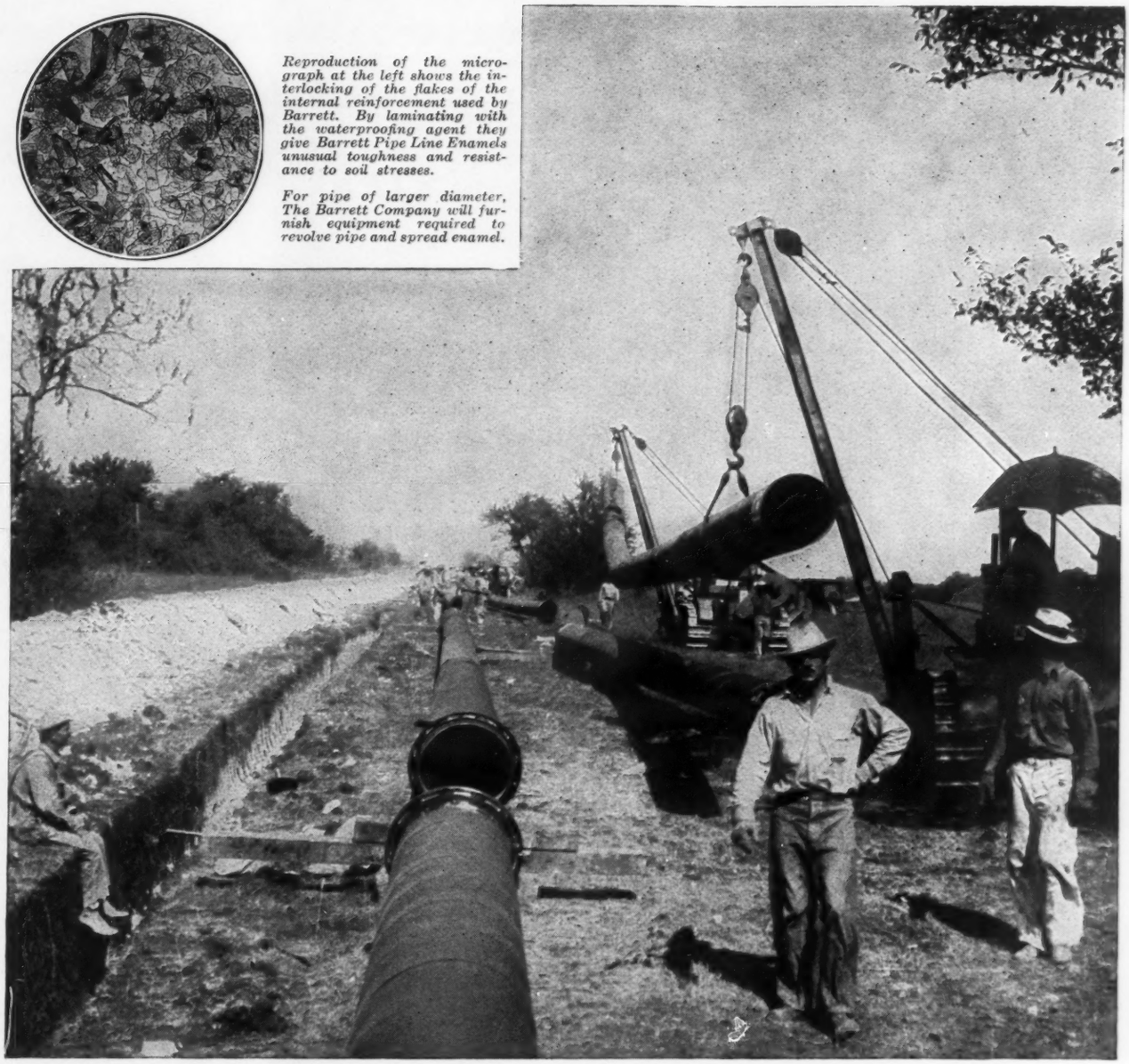
MEMBER: Audit Bureau of Circulation; Associated Business Papers, Inc.

Reproduction of the micrograph at the left shows the interlocking of the flakes of the internal reinforcement used by Barrett. By laminating with the waterproofing agent they give Barrett Pipe Line Enamels unusual toughness and resistance to soil stresses.

For pipe of larger diameter, The Barrett Company will furnish equipment required to revolve pipe and spread enamel.



Courtesy, Lone Star Gas Co.

A pipe line worth laying is worth protecting against corrosion . . .

You can defer reconditioning for many years with a waterproof, dielectric coating of enamel which keeps soil acids, moisture and electric currents away from the metal. The unique laminated structure of Barrett Pipe Line Enamels gives them greater resistance to soil stresses, makes them tougher and more flexible—promotes complete and lasting protection against corrosion. For detailed information, phone, write or wire.

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FIELD SERVICE: Carefully trained Barrett field men will gladly work with you, combining their special knowledge and experience with your familiarity with conditions along the right of way.

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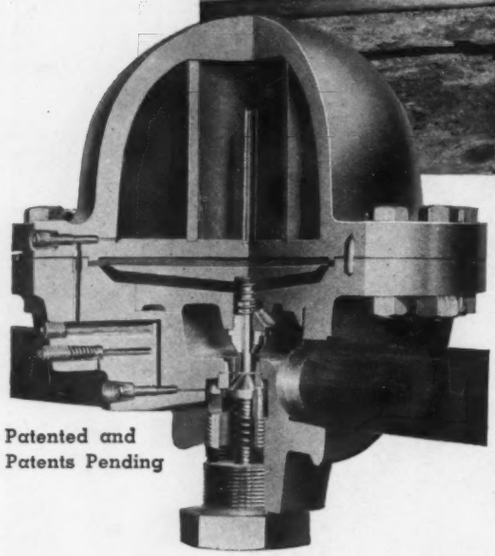
PIPE LINE
ENAMELS

ALL PRESSURES UP TO 3500 LBS.

The "TOPS" in PRESSURE REGULATION



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Unequalled for Reliability

For simplified, trouble-proof gas pressure regulation nothing can surpass a Grove Universal Regulator. Simplicity of construction plus superior workmanship have been combined to give a trouble-proof regulator with extraordinary super-sensitive performance.

Instantaneous changes in demand—from no-flow to full-flow or vice versa — are answered without error. Accuracy is exact regardless of pressure differential. Complete freedom from chatter, pulsation, or "hunt" is assured. Has no stuffing-box or pilot valve to get out of order. Diaphragm cannot be damaged. Valves and seats do not wire-draw.

Easiest to service and make valve renewals when necessary. Entire valve mechanism can be removed and replaced within 5 minutes. No pipe to disconnect. Forged steel bodies add strength.

This regulator can be also furnished for back-pressure services. Ask for Catalog.

SIMPLEST IN DESIGN
ACCURATE AND SENSITIVE
USED ON GAS OR OIL
GIVES DEAD-END SHUT-OFF
NO BLEED TO ATMOSPHERE
NO STUFFING BOXES OR PILOTS
NOT SUBJECT TO FAST EROSION
NOISELESS AND VIBRATIONLESS
FREEDOM FROM "HUNTING"

Ask for Catalog

Explains the Grove Regulator fully, tells how it works, shows how it's built, gives operating characteristics and other important information.

Universal GROVE REGULATORS

GROVE SIMPLICITY ACCURACY SAFETY

This Regulator is based on Patents issued and Patents pending, which are owned by this company. No other manufacturer or agent is authorized or licensed under these Patents.

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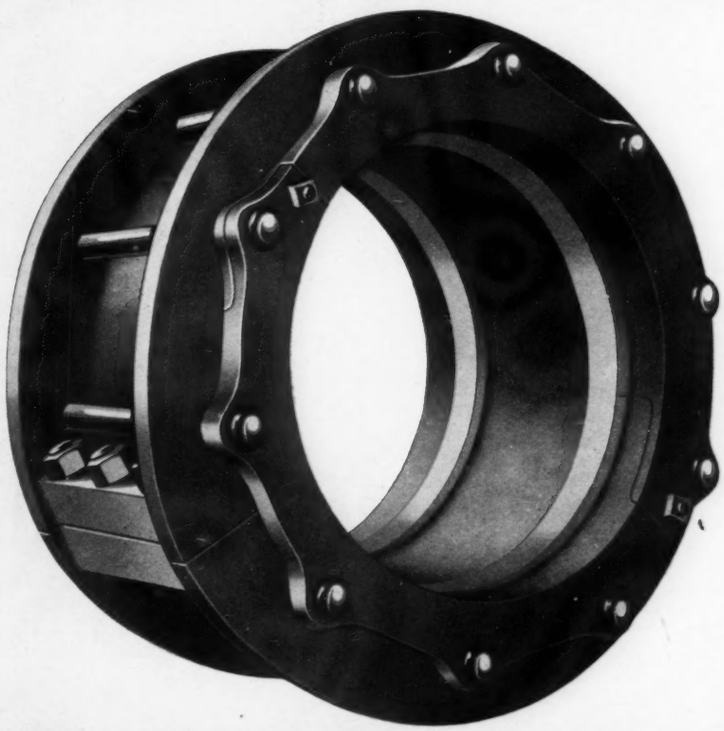
NO. 8½ SPLIT SLEEVES

A Sleeve manufactured of only the highest grade malleable iron . . . that can be quickly applied to broken welds on high pressure lines . . . with the assurance of effecting a permanent repair.



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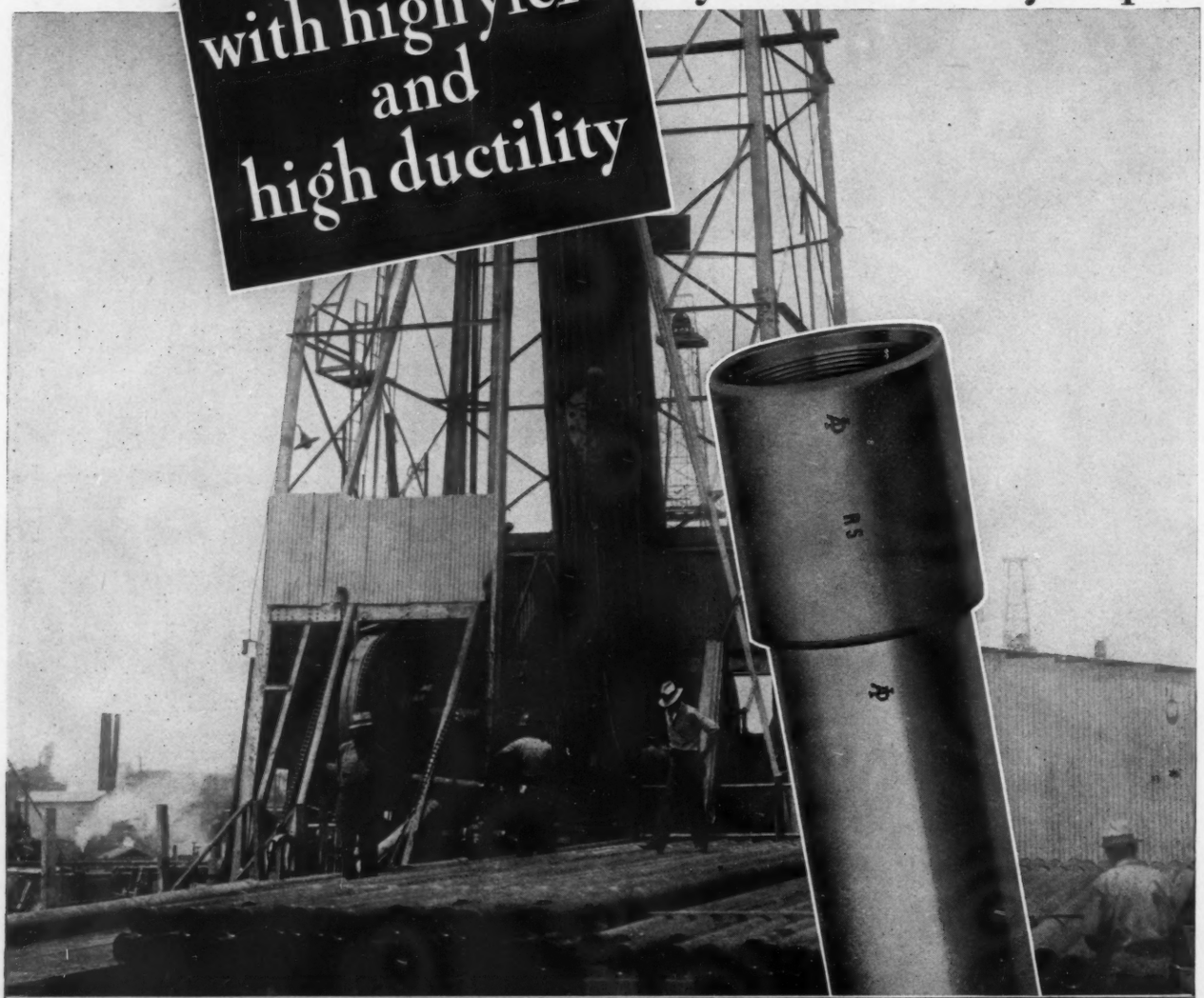
DAYTON PIPE COUPLING DIVISION . . DAYTON · OHIO

use it THE CASING with high yield and high ductility anywhere for any depth



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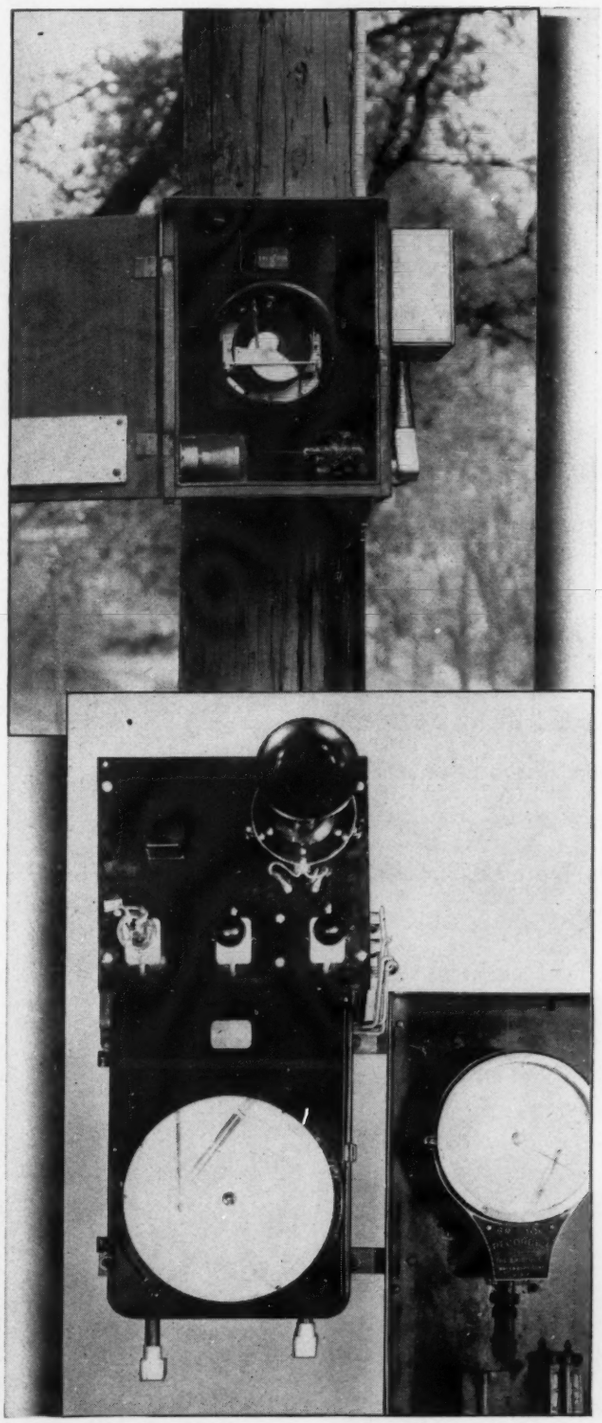
REPUBLIC STEEL

MADE BY PATENTED PROCESS CONTROLLED EXCLUSIVELY BY REPUBLIC STEEL CORPORATION

Republic Steel CORPORATION
GENERAL OFFICES CLEVELAND, OHIO

VISIT THE REPUBLIC EXHIBIT AT THE GREAT LAKES EXPOSITION, CLEVELAND, OHIO . . . JUNE 27th—OCT. 4th.

Harnessing distribution pressures 8 miles away... *lowers pumping costs*



...Another Metameter installation offering you a money-saving suggestion

For checking distribution pressure and holding it within proper limits, one company has installed the transmitter of a Bristol's Metameter on a street pole, as shown above, at the end of the intermediate pressure line—just before the last district regulator. The recording receiver is located in the pumping station, eight miles away.

Now there is no longer any guessing about what's going on. Or about when to operate the pumps. The 12 inch Metameter chart instantly reveals every pressure fluctuation at the distant point. It shows whether this is large or small, abrupt or gradual. It provides an invaluable guide to the station attendant in keeping pumping to a minimum, consistent with satisfactory service.

The resulting savings are so surprising that the chances are you, too, will want further information. Write for Bulletin No. 424-N.

Above: Bristol's Metameter for telemetering distribution pressure measurements to a central headquarters is simple, dependable, *inexpensive*. It consists of:
(*a*) the transmitter, as shown in this illustration,
(*b*) the recording receiver located in the pumping station or other conveniently accessible location, and
(*c*) any simple two wire circuit for conveying measurement impulses from transmitter to receiver. Even an existing telephone circuit may be used.

Left: Here Bristol's Metameter Receiver, mounted in the pumping station, is equipped with an alarm device and howler for signalling when distribution pressure goes out of bounds. The gauge at the right is a Bristol's "Original Form" instrument that has been serving this company faithfully for many years.

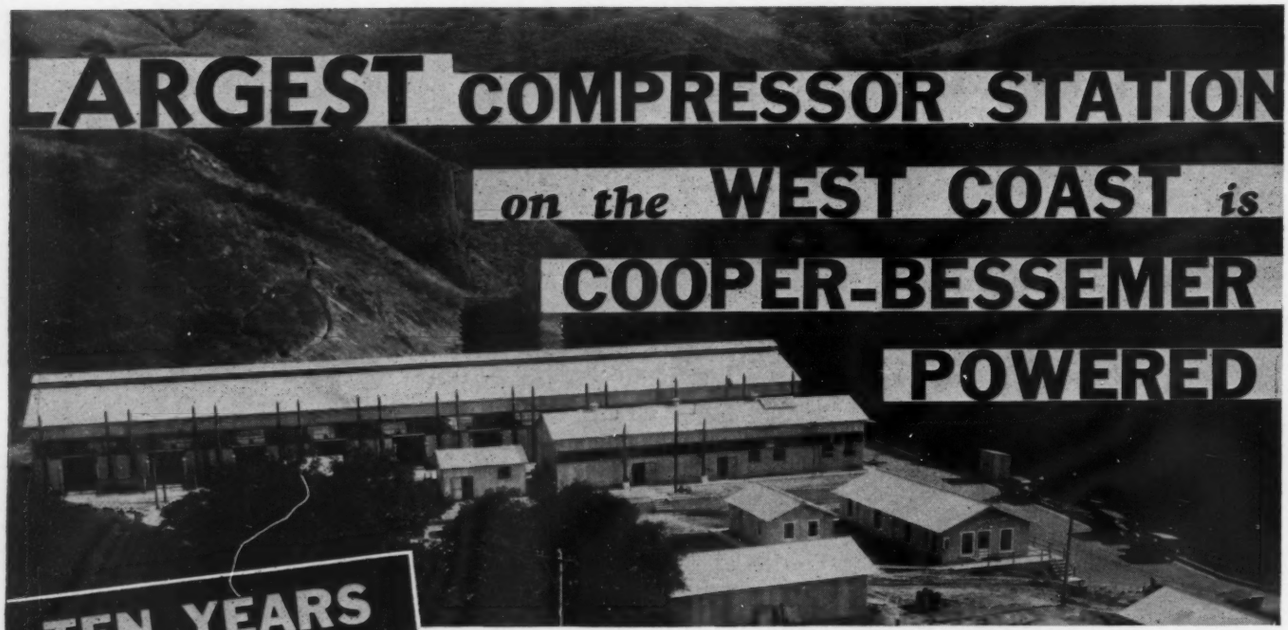
THE BRISTOL COMPANY, WATERBURY, CONN.

Branch Offices: Akron, Birmingham, Boston, Chicago, Detroit, Los Angeles, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco. Canada: The Bristol Company of Canada, Limited, Toronto, Ontario. England: Bristol's Instrument Company, Limited, London, S.E. 14

BRISTOL'S

TRADE MARK REG. U.S. PAT. OFF.

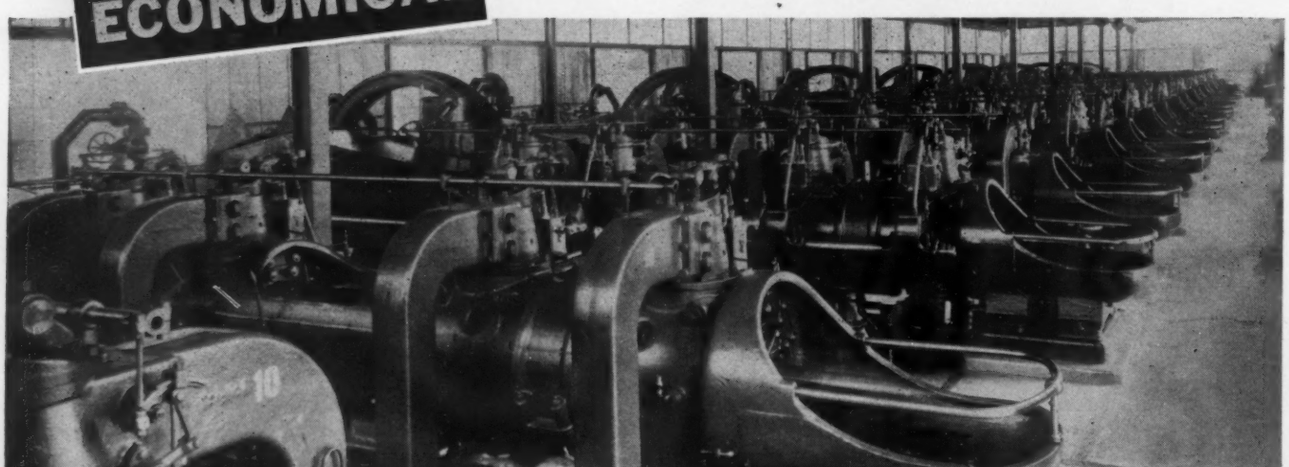
PIONEERS IN PROCESS CONTROL SINCE 1889



LARGEST COMPRESSOR STATION on the WEST COAST is COOPER-BESSEMER POWERED

TEN YEARS of CONSTANT OPERATION Prove "TYPE 19's" Most RELIABLE and ECONOMICAL

It is no surprise to the Ventura Fuel Company that these ten twin-tandem compressor units have behaved so well and have cost so little to operate and maintain. The reliability and low operating costs of Type 19's are well known on the Pacific Coast—where most of the compressor units in the entire natural-gas industry are Cooper-Bessemers. ● For ten years, these compressor units have been sending natural gas to the Los Angeles district. And they are still good for many more years of economical operation. These 760-H. P. Units are almost exact duplicates of the 1000-H. P. Cooper-Bessemer units, except that they are built smaller to make them easier and cheaper to haul and erect.



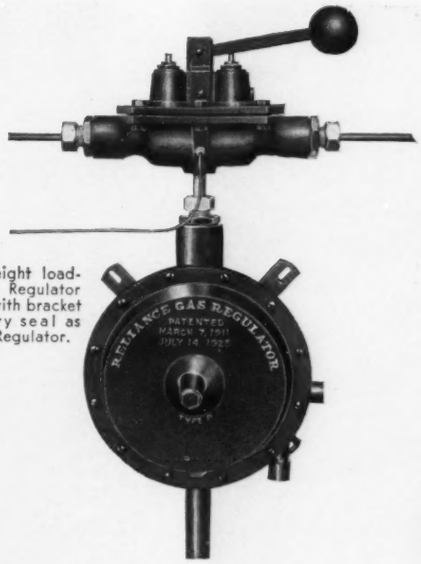
THE COOPER-BESSEMER CORPORATION

640 East 61st Street . . . Los Angeles, California

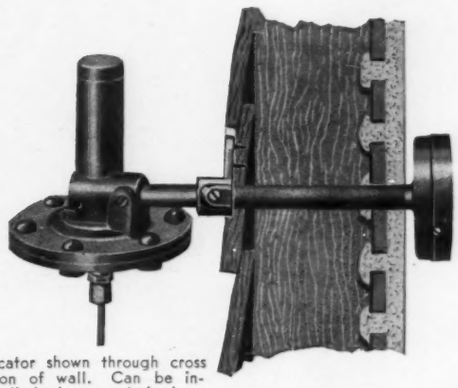
25 West 43rd St., New York City — Mills Bldg., Washington, D. C. — 631 Spring St., Shreveport, La. — 201 East First St., Tulsa, Oklahoma — Magnolia Bldg., Dallas, Texas — Esperson Bldg., Houston, Texas — L. W. Rogers, 6 Finsbury Square, London E. C. 2

Mount Vernon, Ohio — PLANTS — Grove City, Pennsylvania

Mastery of Bottled Gas Pressures



Type MR weight loaded Primary Regulator and Type B with bracket and mercury seal as Secondary Regulator.



Indicator shown through cross section of wall. Can be installed wherever desired.

Indicator Dial.

From Top to Bottom in Two Steps

Full capacity cylinder pressures are stepped down to outlet pressures of from 3 to 10 pounds, and the outlet pressure remains uniform as the cylinder is discharged. Reliance Type MR Primary Regulators installed with Reliance Type B or BK Secondary Regulators permit reduction of outlet pressure to any desired inches of water.

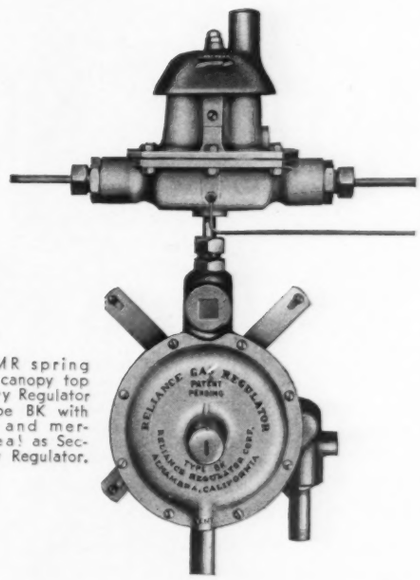
In a two-cylinder system, Type MR Regulators automatically draw on one or both depending on the load and generating capacity of the cylinders. An indicator tapped at any convenient point in the line shows the condition of the supply and enables the user to tell when the reserve cylinder is in service.

For larger than ordinary capacities, Reliance Type MC Primary Regulators are recommended. This equipment is controlled exclusively by Reliance under Patent No. 1,960,466, and is in widespread and satisfactory use with butane and propane gases. Various types for liquid petroleum gas service have been thoroughly tested and approved by the National Board of Fire Underwriters.

For every problem in the regulation of gas pressure, Reliance has the answer in reliable equipment.

Send for complete Bulletins.

RELIANCE REGULATOR CORPORATION
1000 Meridian Avenue, Alhambra, California.



Type MR spring loaded canopy top Primary Regulator and Type BK with bracket and mercury seal as Secondary Regulator.

REGULATORS YOU CAN RELY ON
RELIANCE
SINCE 1918
TRADE MARK

RELIANCE REGULATORS

Otto Jaehnert, superintendent of Mueller's sheet metal shop, talks over a problem in design with Harold Mueller, President.

FATHER WOULD HAVE APPROVED

There have been a lot of changes in heating equipment since my folks started in the business. And every change was marked by a wave of public preference for the prevailing style or convenience at the time.

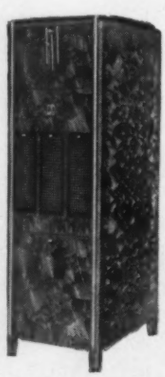
I can still see the ornate gingerbread on the furnaces my grandfather proudly presented to his trade. They marked the change from stoves to central heating plants which delivered warm air to all rooms.

It was a great step forward—and I can still hear the old gentleman laying down his ideas. "You must make it your business to know what your customers want. Then give them what they want if you expect their business." The people of grandfather's day wanted decorative curlycues on their furnaces. They wanted good equipment—and they got it.

The folks of our day want automatic heat and air-conditioning. Evidence of this demand is everywhere. They also want simple modern styling. By following grandfather's precepts, and keeping our eye on the public, we have been abreast of present trends in design and style of heating equipment.

The Mueller line of Gas Era Furnaces and Boilers, together with Climator Air-Conditioning equipment, typifies present day thinking in matters of home heating. It marks an era just as definitely as did the folderol of grandfather's day. Our engineers, alert to trends in heating equipment, have pioneered automatic heat and air-conditioning. They are armed with information and facts which are vitally useful to any utility company going after gas load. Undoubtedly these men can be of help in laying out your program.

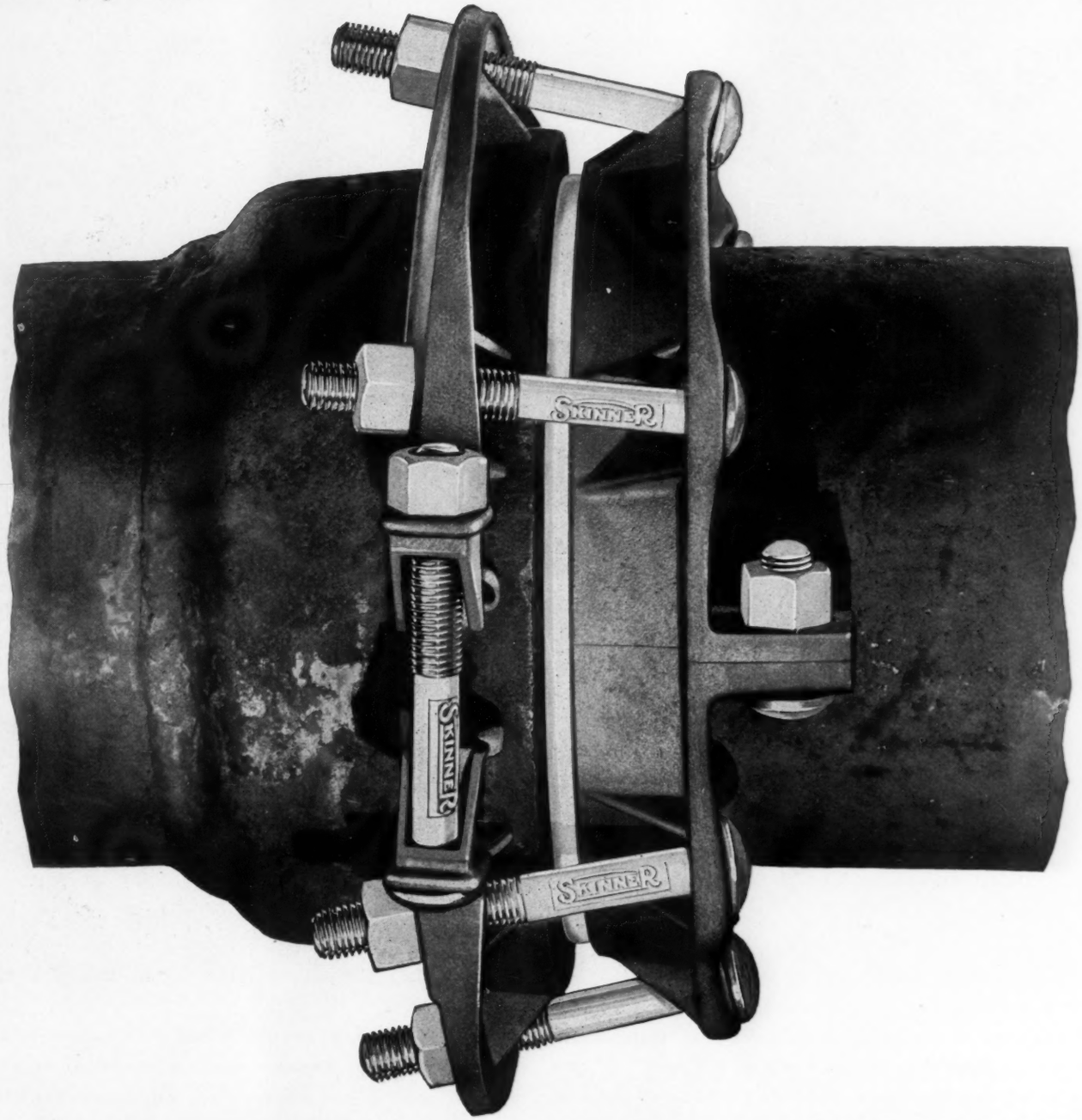
Now is the time to go after automatic gas heat business. The new home building business is getting better every day. Let our engineers and salesmen cooperate with you.



THE NEW MUELLAR-AIRE — A great Load Builder — open tremendous market among stores, shops, showrooms, garages, small factories, and other buildings which do not have a central plant. The Muelleraire is a gas-fired space heater, portable, and beautiful in appearance. We are mighty proud of this Muelleraire and its popularity. The Muelleraire heats, filters and humidifies the air and distributes it throughout the space by forced circulation. Floor-level return insures warm floors.

H. P. Mueller
PRESIDENT

MUELLER-MILWAUKEE



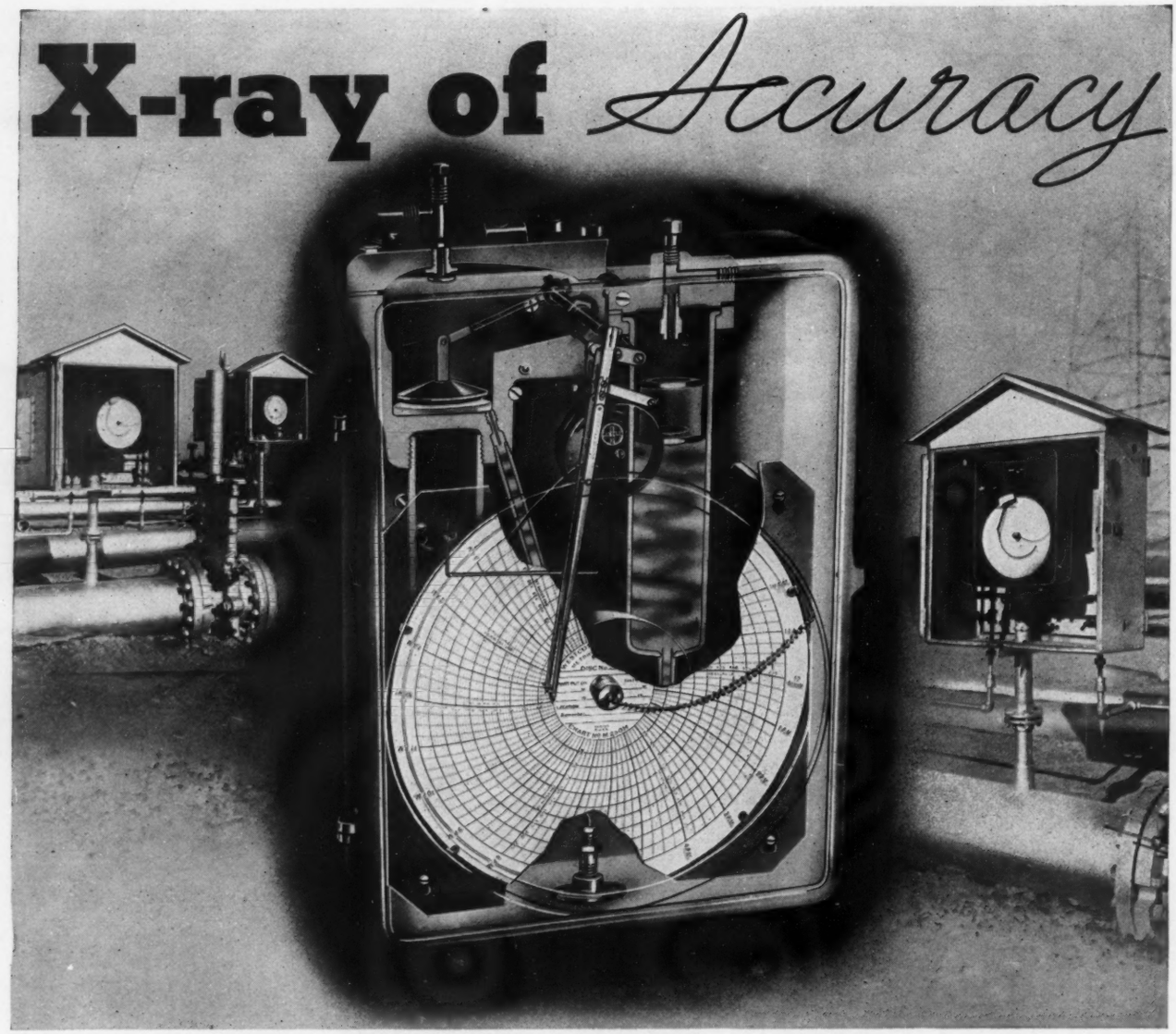
FULLY SEALED!

SKINNER BELL JOINT CLAMPS stop bell and spigot joint leaks instantly and permanently, under pressure! Gasket is SEALED at the bell face by Monel metal band, at pipe by hard vulcanized gasket tip. ¾" Cadmium plated pull bolts. Complete adjustability for variations in pipe diameter reduces number of clamps you have to carry on hand. Speedy one-man application cuts job costs. Write for prices and 1936 catalog.

Cross section shows gasket SEALED at bell face by Monel metal seal ring, at pipe by hard vulcanized tip.

M. B. SKINNER CO. *Est. 1898* SOUTH BEND, IND.

X-ray of *Accuracy*



EXAMINE WHAT IT IS that makes Westcott orifice meters appeal to the man out in the field . . . the meter engineer who sees the difference between instruments in terms of the number of adjustments and the maintenance necessary to KEEP them accurate!

Notice the SIMPLICITY of Westcott meters . . . There's only one moving part between the surface of the mercury and the chart record.

Note too the large float area, with wide clearances eliminating loss of accuracy due to dirt collecting on the mercury . . . the low angle of travel of the float . . . and the small angular travel of the static tube. They make the Westcott meter a PRACTICAL instrument, insuring not only accuracy but ruggedness and complete reliability.

There are a score of minor refinements as well, all of which come under the heading of good instrument making . . . including accurate machining and honing. Meter men take them for granted in Westcott meters . . . but without them the most advanced features of design still could not produce a Westcott meter.

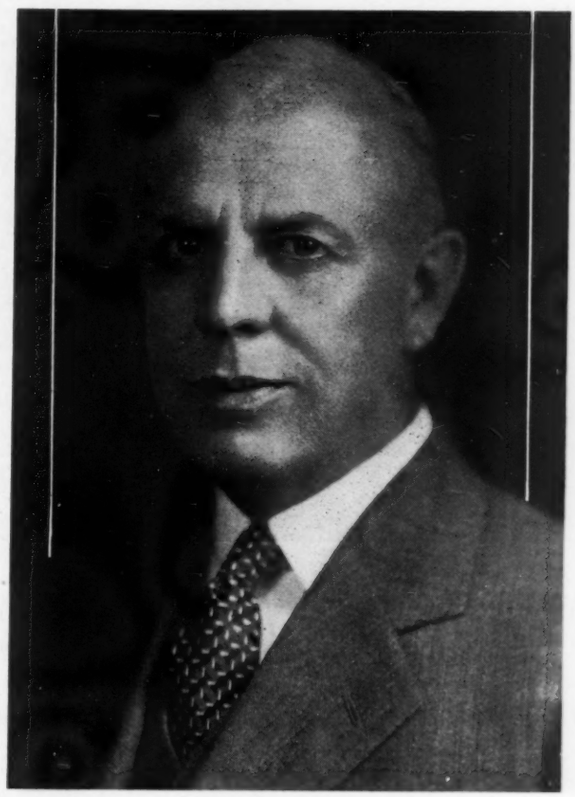
New literature gives complete data. It will be mailed on request. Also, information on the new popular Round Case Indicating Flowmeter.

AMERICAN METER CO. CENTENNIAL 1836-1936

AMERICAN METER COMPANY
INCORPORATED
Measurement and control of Gas, Oil, Steam, Air and Liquids
PACIFIC METER WORKS • LOS ANGELES • SAN FRANCISCO

GAS
August, 1936

Guest Editorial



GAS MARCHES ON

By H. M. CRAWFORD

President, Pacific Coast Gas Association
General Sales Manager, Pacific Gas and Electric Company

YOU and I have read of one or two instances where a small gas system has been abandoned, and electric service has taken its place. I cite this because it brings to my mind clearly what can happen to a neglected business. I dare say that if the truth were known about these abandoned gas systems, we would find out that they had been badly neglected from an operating viewpoint, bled to death financially, and utterly ignored from a sales viewpoint. I can just visualize the bricks piled up on top of an old gas holder which was no doubt full of holes; I can see the steam leaking from all the joints around the old steam boiler; and I can see the old railroad station type of business office. No doubt there were so many leaks in the distribution system that almost as much gas was wasted in the atmosphere as there was being sold through the broken down meters.

The fault did not lie with the gas that was being produced. It was the manner in which it was being produced, distributed and sold. Gas, if properly treated, is superior to any of the other competitive fuels. The trouble with those plants was that they didn't keep up to date; they died from stagnation. They did not keep pace with competition. Competition brings about the survival of the fittest. It's an economic law that forces regular stimulation and constant action if we are to survive.

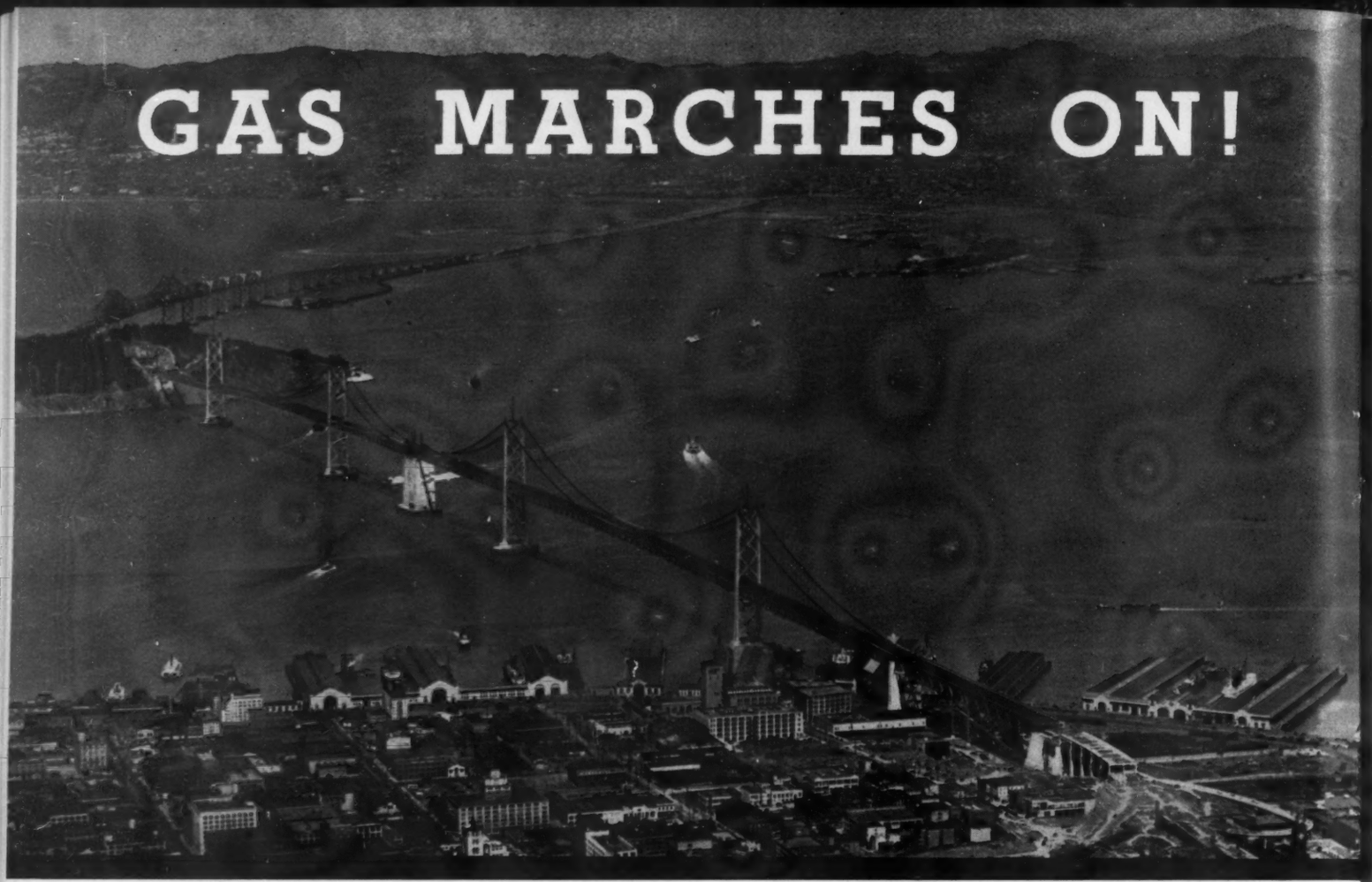
The gas industry as a whole has made remarkable strides in the past few years. Much of this progress can be attributed directly to competition. We have a bulwark of natural advantages on our side, but the competitive wolves are gnawing at the door. They are hungry for a better place in the sun, and here and there they are breaking through our lines, believe it or not. We used to say in our company, when the hazards of electricity were great, that our gas business laid the Golden Egg, but the old days of security in the gas business are gone. The gap between the cost of gas service and other fuels has been rapidly closing and you gentlemen in the gas business know this is not an idle statement.

MODERN, up-to-the-minute salesmanship, I believe, is one of the chief things that has been lacking in our business, not so much on the part of the utilities themselves, but more particularly with the great mass of dealers who in reality are our greatest potential sales force. It has been my experience, with some notable exceptions, that dealer salesmen, who should be the strongest link in the sales chain, are actually the weakest link. It is an unfortunate situation when we know that millions of dollars are being poured into advertising and sales promotional work by the industry, and then find that the prospects thus developed are being turned over to a retail sales person not equipped to complete the most important transaction —that of actually making the sale. We must break that bottleneck which exists at the point of sale.

We have a mutual interest in the education of these dealer sales people, especially so in view of the highly competitive conditions with which we are confronted today. I know of one organization in the electrical industry which has taken upon itself the task of educating dealer sales people. They have been conducting schools in modern salesmanship for dealer sales people throughout the territory of one large utility. I believe this is an excellent and very constructive work and it is a thing badly needed in our business. Most of the dealer sales people are selling enameled cast-iron appliances rather than the *benefits* which can be obtained by their use with modern gas fuel.

At the forthcoming Pacific Coast Gas Association convention to be held in San Francisco August 25-28, I hope this subject will be given some discussion. Recognizing, as we do, that we are in a competitive fight, we are hoping to make this convention a rally of the gas men on the Pacific Coast. We cannot overstress the necessity of working together to overcome those problems that are common to the industry and which must be solved to achieve our purpose. It is partly in recognition of this need for continued progress, as well as in tribute to the very tangible accomplishments the industry has recorded in recent years, that there has been selected as keynote for the 43rd convention the phrase—"Gas Marches On."

We are planning what we think will be a very interesting, educational, and enjoyable program for this convention. There will be a number of very fine treatises presented during the proceedings on engineering, accounting, economic, commercial and sales problems. Mr. James B. Black, President of the Pacific Gas and Electric Co., will welcome the delegates and their families to San Francisco. *(Continued on Page 106)*



Foremost attractions of the P. C. G. A. convention locale this year are the Bay Bridges. Seen above, from the San Francisco side approach, is the $77,600,000 San Francisco-Oakland Bay Bridge, which will open to automobile traffic early in November. (Photo courtesy of California Toll Bridge Authority).

WHAT THE 43rd CONVENTION OFFERS

"GAS Marches On!"

Around this central and challenging theme the Pacific Coast Gas Association has built a program for its 43rd annual convention which will make these coming meetings a powerful stimulus for aggressive gas promotion on the West Coast during the year ahead.

This year the P.C.G.A. sessions take place in San Francisco, under the hospitable roof of the Fairmont Hotel. Located "a-top of Nob Hill," the Fairmont will spread a colorful panorama of Bay and city before conventioneers. The dates are August 25, 26 and 27 for the business program, with the annual golf tournament falling on the morning of August 28 at the Lakeside Golf Club. On the afternoon of the same day a premier attraction of the convention will be offered in a boat trip on San Francisco Bay, inspecting the San Francisco-Oakland Bay Bridge and Golden Gate Bridge construction now in advanced stages, and the future site of the 1939 Golden Gate International Exposition.

In this pre-convention edition of *G A S* are presented, as in years past, a number of the Association's committee reports and papers which will appear on the San Francisco program. (See Pages 19-88). Through this pre-publication plan it is intended to stimulate convention discussion of these valuable program features, and the Association membership is urged to give them a thorough advance reading.

Convention duties this year are in the hands of an ably-staffed committee with Henry Bostwick as general chairman, assisted by the following: C. B. Babcock (entertainment); Frank Talcott (reception and attendance); E. J. Hinchey (golf); E. C. Wood (transportation); Jean Frickelton (publicity); Wayne Clark (registration); F. J. Southerland (properties); W. A. Worthington (hotel accommodations); A. C. Joy (convention newspaper); B. W. Reynolds (banquet). Mrs. H. M. Crawford is serving as convention hostess.

Below is a tentative program, complete in most particulars. It brings together a strong aggregation of gas industry talent, which together with the P.C.G.A. tradition of enjoyable conventions, should insure a record attendance on hand when President Crawford calls the convention to order.

GENERAL SESSIONS

TUESDAY . . 10:00 A.M.

The Streets of San Francisco (Bringing the Streets to Life)—An original skit written and presented by Ronald Telfer.

Cast: Phoebe Clark, Edwin Macdonald, Aileen Poole, Carola Beetz, Laura Kirkpatrick and Ronald Telfer.

Welcome to San Francisco—James B. Black, President, Pacific Gas and Electric Co.

President's Address—H. M. Crawford, President, Pacific Coast Gas Association.

Election of Officers.

Address—Leon O. Whitsell, Member California Railroad Commission.

In Memoriam.

TUESDAY . . 2:00 P.M.

The First Two Years of the "New Utilities Tax"—M. D. Lack, Manager Tax Department, Pacific Gas and Electric Co.

Physiological Effects of Natural Gas—Dr. D. R. Drury, Professor of Physiology, University of Southern California.

The Legislative Trend—T. J. Straub, General Counsel, Pacific Gas and Electric Co.

What Women Want to Know—Genevieve Callahan, Editor, Sunset Magazine.

National Advertising at Last—Jas. F. Pollard, President, Seattle Gas Co., and member Committee on National Advertising.

WEDNESDAY . . 9:30 A.M.

CUSTOMERS RELATIONS CONFERENCE

Under Auspices of the Educational Committee

E. G. McCann, Chairman

Service Sampling—R. R. Blackburn, Southern California Gas Co.

Progress in Employee Training—R. L. Eltringham, Pacific Gas and Electric Co.

A Discussion of Practical Educational Procedure—R. V. Davis, Los Angeles Gas and Electric Corp.

An Educational Program for Architects and Builders—Frank Moon, Los Angeles Gas and Electric Corp.

Address—Arnold Perstein, Professor of Public Speaking, University of California.

WEDNESDAY . . 12:15 P.M.

GROUP LUNCHEON—A. C. Joy, Chairman.

THURSDAY . . 9:30 A.M.

Manufacturers Trade Associations—W. J. Bailey, General Chairman, Manufacturers Section.

Guiding the Sales Program—B. W. Reynolds, Manager, Dealer Sales Promotion, Pacific Gas and Electric Co.

Gas Rate Economics—W. G. Vincent, Jr., Vice-President and Executive Engineer, Pacific Gas and Electric Co.

"Twenty Million Years"—A Sound Picture of the Gas Industry Prepared by the Los Angeles Natural Gas Bureau.

THURSDAY . . 12:15 P.M.

GROUP LUNCHEON—Dan Scott, Chairman.

THURSDAY . . 7:00 P.M.

ANNUAL BANQUET, followed by dancing in the Terrace Garden.

ACCOUNTING SECTION

WEDNESDAY . . 2:00 P.M.

Address of Chairman—Lester E. Green, Assistant to Manager Customers Department, Los Angeles Gas and Electric Corp.

Discussion of Credit Problems on Long Term Appliance Contracts—Led by C. T. Burns, Southern California Gas Co.

Customer Accounting as It Affects Public Relations—O. L. Moore, Los Angeles Gas and Electric Corp.

Trends in Accounting Classifications—D. G. Martin, Pacific Gas and Electric Co.

THURSDAY . . 2:00 P.M.

Customer Deposit Policies—M. W. Gibson, Seattle Gas Co.

Standardization of General Service Forms—M. A. Seeley, Los Angeles Gas and Electric Corp.

Payroll Accounting Under Social Security Requirements—A discussion led by L. W. Coughlan, Pacific Gas and Electric Co.

MANUFACTURERS SECTION

WEDNESDAY . . 2:00 P.M.

Address of Chairman—W. J. Bailey, President, Day and Night Water Heater Co.

Report of Nominating Committee—F. C. Packer, Chairman.

Collection of Appliance Sales Statistics—C. A. Swigart, Trade Relations Representative, Pacific Coast Gas Association.

Trends in Appliance Design—Dr. F. E. Vandaveer, Supervisor, American Gas Association Testing Laboratory, Los Angeles.

Should a "Sales Slant" Be Given the Blue Star?—A. E. Higgins, Secretary Natural Gas Department, American Gas Association.

W. M. JACOBS
Sales, Advertising Section Chairman

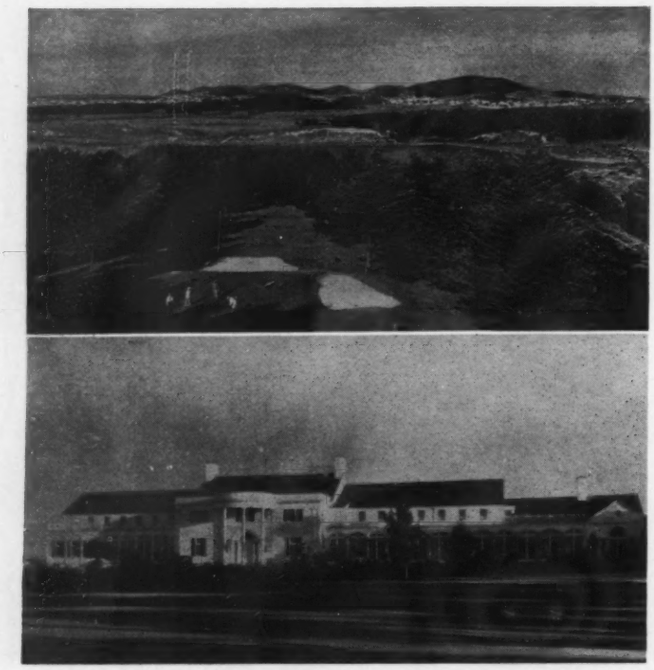
LESTER E. GREEN
Accounting Section Chairman

P. E. BECKMAN
Technical Section Chairman

W. J. BAILEY
Manufacturers' Section Chairman

A. C. JOY
Chairman, Cooperative Advertising

E. G. McCANN
Chairman, Educational Committee



The Olympic Club's Lakeside golf course (see 8th green and fairway of Lake course, above) will get the P. C. G. A. tournament play on Friday, August 28. California Golf Club (lower view) will also be open to Association players during the convention period.

SALES & ADVERTISING

WEDNESDAY . . 2:00 P.M.

Address of Chairman—W. M. Jacobs, Assistant General Superintendent of Sales, Southern California Gas Co.

Budgeting Sales Effort—E. J. Strickland, Southern California Gas Co., Chairman, Domestic Sales Committee.

A Method for Measuring the Effectiveness of Sales Supervisors—Frank Talcott, Pacific Gas and Electric Co.

Following New Construction for Sales—Lew Galbraith, Pacific Gas and Electric Co.

"A-top of Nob Hill" stands the Fairmont . . . convention headquarters.

Following Turn-ons for Sales—David N. Reid, Pacific Gas and Electric Co.

Home Service on the Pacific Coast—Victoria Warner, Los Angeles Gas and Electric Corp., Chairman, Home Service Committee.

Luncheon Programs to Promote Sales—Beatrice Strege, Seattle Gas Co.

Home Service and Dealer Cooperation—Gladys Price, Southern California Gas Co.

THURSDAY . . 2:00 P.M.

Analysis of Advertising Media—Forrest Raymond, San Diego Consolidated Gas and Electric Co., Chairman, Advertising Committee.

Symposium on Radio Advertising—Led by A. C. Joy, Pacific Gas and Electric Co.

The Industrial Data Sheet Program—R. L. Grutzmacher, Natural Gas Equipment, Inc., Chairman, Industrial Sales Committee.

Engineering Data for Use in Sales Work—C. C. McRae, Pacific Gas and Electric Co.

What Sales Expense Is Justified in Securing Small Commercial Loads?—Ray Trowbridge, Seattle Gas Co.

Industrial Utilization of Gas—W. T. Newton, Pacific Coast Engineer, American Can Co.

Heating Equipment for Commercial Buildings—W. L. Howe, Pacific Gas and Electric Co.

TECHNICAL SECTION

TUESDAY . . 7:30 P.M.

UTILIZATION CONFERENCE

Report of Utilization Committee—Guy Corfield, Chairman, Los Angeles Gas and Electric Corp.

Report: Gas Lighting—C. A. Thorp, Chairman, Los Angeles Gas and Electric Corp.

*Equipment and Methods for Gas Service Training—J. E. C. Currens and C. P. Perkins, Pacific Gas and Electric Co.

Report:, *Thermostats for Gas Space Heater—T. G. Wallace, Los Angeles Gas and Electric Corp.

WEDNESDAY . . 2:00 P.M.

Address of Chairman—P. E. Beckman, Assistant Engineer, Pacific Gas and Electric Co.

Report of Production Committee—Geo. R. Horning, Chairman, Seattle Gas Co.

Report of Distribution Committee—Otto Goldkamp, Chairman, San Diego Consolidated Gas and Electric Co.

Report: Breaking in Gas Meters Before Final Adjustment of Proof—H. S. Harris, Chairman, Los Angeles Gas and Electric Corp.

Advisability of Changing Gas Meters on Basis of Gas Passed—F. S. Honberger, Southern California Gas Co.

*The Resistance of Pilot Lights to Air Currents—C. Eldon White and C. W. Stewart, San Diego Consolidated Gas and Electric Co.

Economics of Unaccounted-for-Gas—F. A. Hough, Southern Counties Gas Co.

Combustible Leak Detectors—M. T. Burton, Southern California Gas Co.

* Printed in current issue of *GAS*.

Report: Modern Methods for the Installation of Mains and Service—Frank Pape, Chairman, Pacific Gas and Electric Co.

Maintenance of Cast Iron Mains—H. F. Carr, Pacific Gas and Electric Co.

The Installation of Gas Mains Under Pavement—H. V. Buffington, Los Angeles Gas and Electric Corp.

Replacement of Services Under Pavement—J. E. O'Brien, Pacific Gas and Electric Co.

Report: Pressure Piping Code—C. P. Perkins, Chairman, San Diego Consolidated Gas and Electric Co.

Fire Prevention Demonstration: Immediately after the adjournment of this session a Fire Prevention Demonstration will be made at the Pacific Gas and Electric Co.'s yard at 18th and Shotwell Streets. This demonstration will be supervised by J. E. C. Currens, Pacific Gas and Electric Co.

THURSDAY . . 2:00 P.M.

Report of Transmission Committee—A. B. Allyne, Chairman, Southern Counties Gas Co.

Pipe Protection Subcommittee—C. P. De Jonge, Chairman, San Diego Consolidated Gas & Electric Co.

*Locating Accidental Contacts on Cathodically Protected Lines—H. J. Keeling, Southern Counties Gas Co.

The Effect of Soils on Asphalt—D. R. Hiskey, Southern California Gas Co.

Compressor Plants and Pipelines Sub-Committee—B. M. Laulhere, Chairman, Southern California Gas Co.

*Leaks on Natural Gas Transmission Mains—Fred E. Wilson, Pacific Gas and Electric Co.

*Clearance Pockets for Transmission Line Compressors—H. J. Smith, Pacific Gas and Electric Co.

*Gas Dehydration by Calcium Chloride Brine Method—W. K. Dodd, Southern California Gas Co.

*The Internal Corrosion of Natural Gas Transmission Pipelines—M. T. Burton, Southern California Gas Co.

*Natural Gas Calorimetry Sub-Committee—Guy Corfield, Chairman, Los Angeles Gas and Electric Corp.

*Effect of Atmospheric Humidity in Gas Calorimetry—W. A. McGlashen, Los Angeles Gas and Electric Corp.

*Orifice Meter Standards Sub-Committee—E. H. Fisher, Chairman, Coast Industrial Gas Co.

*Application of the Reynolds and Expansion Factors in Gas Measurement—E. H. Fisher, Coast Industrial Gas Co.

*Effect of Air Density on the Measurement of Specific Gravity of Gases—R. P. Work, Coast Industrial Gas Co.

* Printed in current issue of *GAS*.

WOMEN'S COMMITTEE

THURSDAY . . 8:00 A.M.

Women's Committee Breakfast.

THURSDAY . . 2:00 P.M.

Address of Chairman—Alma Freeburg, Coast Counties Gas and Electric Co.

Reports of Standing Committee Chairman.

Reports of Company Committee Chairman.

Roundtable Discussions.

LADIES' PROGRAM

TUESDAY, 3:00 P.M.—Fashion Tea, Room of the Dons, Hotel Mark Hopkins.

WEDNESDAY—Putting contest and luncheon at Lakeside Country Club, followed by tour of San Francisco.

THURSDAY—Luncheon and bridge at the Western Women's Club.

THURSDAY, 7:00 P.M.—Annual Banquet and Ball.

FRIDAY, 1:30 P.M.—Boat trip on San Francisco Bay, to inspect bridges and grounds for the 1939 Golden Gate International Exposition.

* Printed in current issue of *GAS*.

Looking northeast at the Golden Gate Bridge. (View taken from the Lincoln Park Golf Course at Lands End, entrance to the Golden Gate).

B. C. Electric Power & Gas Co.'s model all-gas home, at 39th and Highbury, Vancouver, was officially visited by the convention on the afternoon of July 9. Bob Normington played host.

The Howe Sound cruise on the S. S. Princess Kathleen will be long remembered. Here is B. C. Electric's gas band, which entertained on the after deck of the Kathleen during the trip.

GAS CAMERA Goes to Vancouver

See Story (Page 101) of Canadian Gas Association and Pacific Coast Gas Association Joint Meetings.

Two Canadian Association presidents, snapped in the Carrall Street gas plant yard. (Left) Hugh McNair, manager gas utilities, Winnipeg Electric Co., C.G.A. president 1932-33. (Right) John Keillor, C. G. A.'s outgoing president, gas engineer and manager, B. C. Electric Power & Gas.

What would a convention be without golf! Above we see American Stove's Ed Milliken (San Francisco) with Coast Counties Gas and Electric's Roy Dreiman and Al Strong (Santa Cruz), just before the battle.

Left to right, against a Howe Sound background, stand Payne Furnace and Supply's El Roy Payne, American Gas Association's Dr. F. E. Vandaveer, Pacific Coast Gas Association's Carl Swigart, and A. G. A. Lab. Director R. M. Conner.

B. C. Electric tells the world in letters several feet high that gas is the modern fuel, as seen on its Carrall Street holder.

Beside Hotel Vancouver, H. M. Thomas of Northwest Cities Gas (Walla Walla) and Ben Parkinson of Portand G. & C. pose for the inquisitive camera.

Promenading the S. S. Kathleen deck we see W. M. Jacobs, sales dept. luminary of So. Calif. Gasco, and Ed. Hinchey of Wedgewood fame.

Home from the Canadian convention, Seattle Gas Co.'s Jim Pollard points out the sights from the roof of his local athletic club building.

PACIFIC COAST GAS ASSOCIATION

Presenting a number of reports and papers from the Technical Section, prepared for the 43rd annual convention . . . San Francisco, Aug. 25-28

Resistance of Pilot Lights to Air Currents

By C. ELDON WHITE *and* C. W. STEWART
San Diego Consolidated Gas and Electric Company

A LARGE proportion of domestic trouble calls are due to pilot light failures. The difficulty with pilots burning natural gas is the flame of low velocity, which is too easily blown out even by a moderate puff of air. The development of a completely reliable pilot light would be of considerable value to the industry, promoting better customer satisfaction, and increasing the safety of gas appliances. A pilot light which would eliminate one trouble call per annum would be economical at a cost of perhaps $2.

This investigation covers a number of pilot lights burning natural gas of about 0.69 specific gravity and 1130 B.t.u. heating value. The results and conclusions reached are entirely practical; no theoretical explanation is attempted for the relatively good or poor performance of the pilots.

The original purpose of this paper was an investigation of the possibility of developing a universal pilot light. We do not treat here of the failure of pilot lights due to dust stoppages. Although dust is undoubtedly an important factor in the failure of pilot lights, it soon became apparent that the resistance of pilots to drafts of air was important enough to justify our concentrating upon the latter for the present. We believe the puff of air to be a better laboratory measure of the stability of a pilot light than a steady stream of air, because the latter cools the pilot abnormally, giving unduly unfavorable results. The use of the puff considerably expedites the rapid classification of pilots. Our experience leads us to believe that those air currents which extinguish pilot lights are puffs of air rather than steady drafts. The purpose of this report, therefore, is to show which type of pilot we have so far found most resistant to puffs of air, and the history of its development.

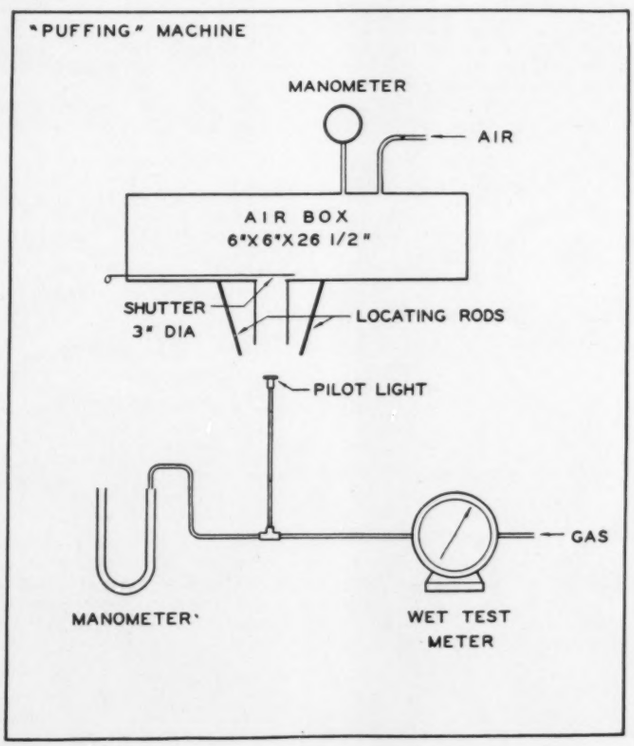


FIG. 1.

OTTO GOLDKAMP
Distribution

A. B. ALLYNE
Transmission

GUY CORFIELD
Utilization

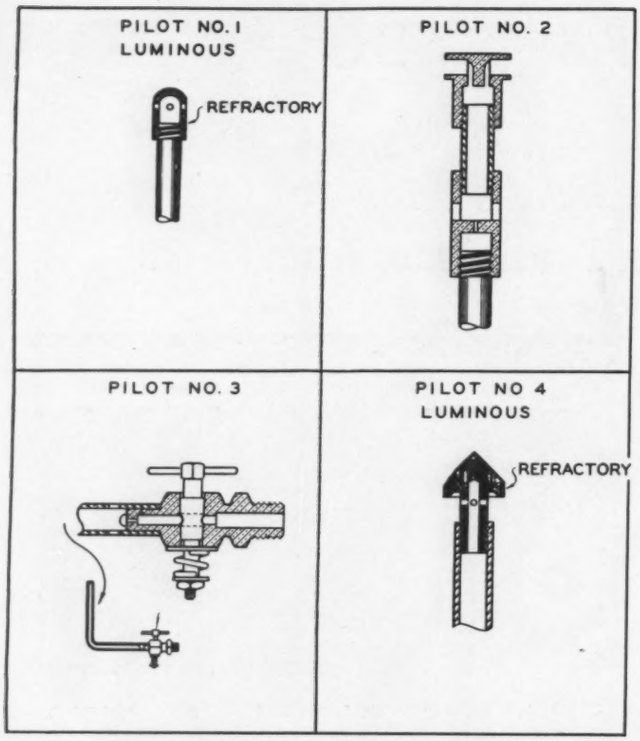
WORK OF THE Pacific Coast Gas Association's Technical Section is carried on principally through four main committees—Distribution, Transmission, Utilization, and Production. Otto Goldkamp, San Diego Consolidated Gas and Electric Co., heads the Distribution Committee; Arthur B. Allyne, Southern Counties Gas Co., the Transmission; Guy Corfield, Los Angeles Gas and Electric Corp., the Utilization; and Geo. R. Horning, Seattle Gas Co., the Production Committee. The first three committees are represented in the papers which appear in this section of GAS.

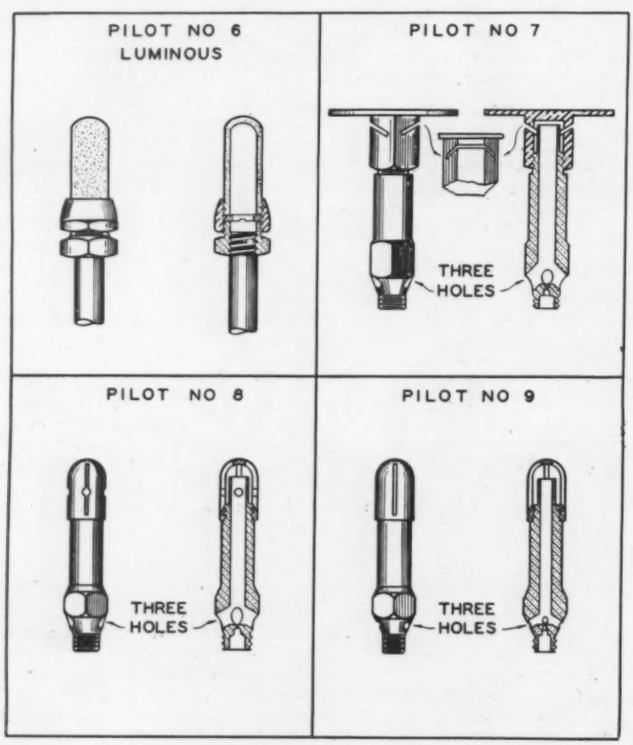
Apparatus

We have tested a number of pilots with our laboratory puffing machine.* The puffing machine (see Fig. 1) consists of a box with a quickly acting shutter, a manometer to determine the air pressure inside the box, and locating rods for the placing of the pilot flame.

Each pilot was carefully adjusted, placed at a constant distance from the draft, and subjected from three angles to puffs of air of varying magnitude. The angle was varied by moving the box rather than the pilot, permitting the latter always to burn in its normal position. Natural gas was supplied at 3, 6, and 9 inches water column respectively, except for luminous pilots, which were adjusted by an experienced pilot man to low, medium, and high flames. The rate of flow was noted by means of a wet test meter. To operate the machine, the shutter was closed, air was admitted to the box to the desired pressure, and the shutter was quickly opened by means of the spring opening device. If the flame was extinguished a lower air pressure inside the box was tried, until finally a pressure was reached below which the flame was not extinguished. This was considered, after two check tests, to be

* The puffing machine was built by Frank Bater.





the resistance of the pilot light under the particular conditions of the test. The higher this puff, the more resistant the pilot to such air currents. This resistance was noted to the nearest half inch.

The puffing machine does not measure the resistance of pilot lights in absolute units, but it does furnish a uniform method of classifying pilots with reference to their resistance to puffs of air.

The series of sketches shows the pilots which were tested in this manner.

Table No. 1 shows the results obtained in testing pilot lights with the puffing machine.

TABLE NO. 1. SUMMARY OF DATA.

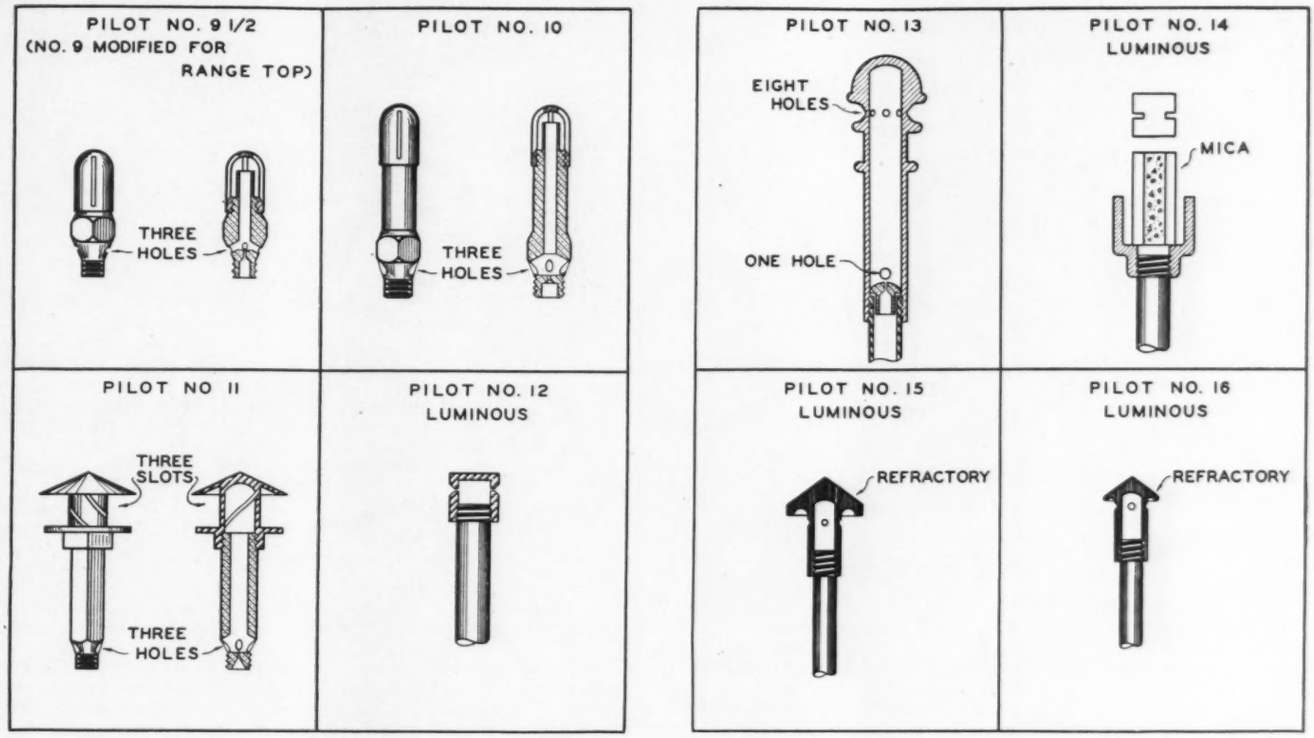
Pilot No.	Pressure at Burner (Inches Water)	Cu. Ft. Gas per Hour	Max. Resistance of Pilot to Puff of Air in Terms of Air Pressure. (Inches Water Column)		
			Down Draft	Horizontal Draft	Up Draft
1	Luminous	0.27	4.0	3.5	4.0
	Luminous	0.50	4.0	3.5	4.0
2	3	0.73	5.5	7.0	6.5
	6	1.15	5.5	7.0	11.0
	9	1.42	5.5	10.0	10.0
3	3	0.50	3.5	3.0	6.5
	6	0.62	3.0	3.0	5.5
	9	0.85	3.0	3.0	6.5
4	Luminous	0.40	3.5	3.5	1.0
	Luminous	0.74	4.5	4.0	8.0
6	Luminous	0.39	3.0	3.5	4.0
	Luminous	0.64	4.0	3.0	4.0
7	3	0.47	9.0	7.0	6.0
	6	0.72	7.0	9.0	6.0
	9	0.92	8.5	8.0	6.5
8	3	0.35	3.0	2.5	3.0
	6	0.47	3.0	4.0	2.5
	9	0.62	3.9	4.0	3.5
9	3	0.31	2.5	3.0	3.5
	6	0.42	2.5	3.5	3.5
	9	0.56	3.0	3.0	4.0
10	3	0.27	2.5	4.0	3.0
	6	0.46	3.0	3.5	3.0
	9	0.56	3.0	3.5	3.0
11	3	0.88	7.5	5.5	5.0
	6	1.38	7.5	6.0	7.0
	9	1.75	9.0	6.5	9.0
12	Luminous	0.23	2.5	1.5	1.5
	Luminous	0.53	2.5	2.5	2.5
	Luminous	1.1	2.5	2.5	2.5
13	3	0.92	4.5	4.0	4.0
	6	1.50	3.5	4.0	4.0
	9	1.74	5.0	4.5	5.0
14	Luminous	0.42	3.0	3.0	3.0
	Luminous	0.81	3.0	4.0	4.5
	Luminous	1.30	3.0	4.0	5.0
15	Luminous	0.37	3.5	4.0	2.5
	Luminous	0.63	4.1	4.0	3.0
	Luminous	0.96	4.0	4.5	3.0
16	Luminous	0.34	3.5	3.0	2.5
	Luminous	0.55	3.5	3.0	3.0
	Luminous	0.93	4.0	3.5	3.0
17	Luminous	0.23	2.5	0.0*	0.0*
	Luminous	0.35	2.3	2.5	3.5
	Luminous	0.67	3.0	3.0	4.0
21	3	0.47	8.0	7.0	9.0
	6	0.74	9.5	9.0	12.0
	9	0.85	10.0	9.5	9.0

*No. 17 extinguished by sound waves.

In Table No. 2, a preferential classification of pilots is given. The degree of preference is based upon the pilots' resistance to puffs of air in terms of air pressure and inches of water column. The conditions of test included 3, 6, and 9 inches of gas pressure (low, medium, and high) together with draft directions of all angles, downward, horizontal, and upward.

Discussion of Results

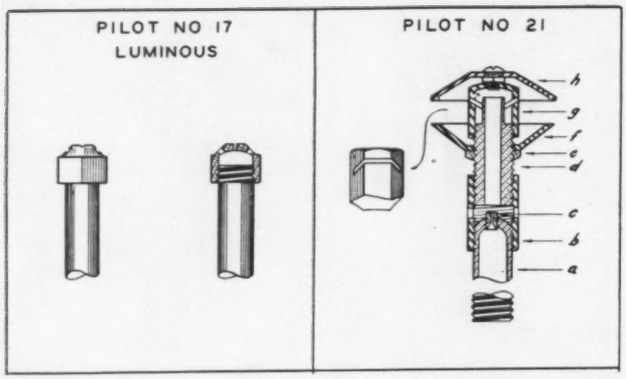
The majority of the pilots tested, regardless of whether they were luminous or of the Bunsen type, showed poor resistance to puffs of



air, *viz.*, 6 inches or less on our puffing scale. Of the pilots tested, some were more resistant to down drafts, some to horizontal, and some to up drafts. In general, for any individual pilot, the resistance to puffs from the same angle does not decrease, but rather increases, with increased gas consumption; but different pilots at the same pressure behave quite diversely. Luminous flame pilots generally offer poor resistance to puffs of air, although not all the Bunsen pilots show good resistance to puffs. Very low gas consumption invariably means poor resistance. There is no especial relationship between medium to high gas consumption (greater than 0.6 cubic feet per hour) and resistance to puffs of air. Pilot construction is more important to insure good resistance to stray air

TABLE NO 2. PREFERENTIAL CLASSIFICATION OF PILOTS

Pilot Pressure	Puff Direction		Worst																Best
			Increasing Resistance to Puffs of Air →																
Low	All Angles	Pilot No.	17	4	12	9	8	10	16	15	14	3	6	1	13	11	2	7	21
		Puff, in. H_2O	0.0	1.0	1.5	2.5	2.5	2.5	2.5	2.5	3.0	3.0	3.5	3.5	4.0	4.5	5.5	6.0	7.0
Low	Down Draft	Pilot No.	17	12	9	10	8	14	6	4	16	15	3	1	13	2	11	21	7
		Puff, in. H_2O	2.5	2.5	2.5	2.5	3.0	3.0	3.0	3.5	3.5	3.5	3.5	4.0	4.5	5.5	7.5	8.0	9.0
Low	Horiz. Draft	Pilot No.	17	12	8	9	16	14	3	1	6	10	15	13	4	11	2	7	21
		Puff, in. H_2O	0.0	1.5	2.5	3.0	3.0	3.0	3.0	3.5	3.5	3.5	4.0	4.0	4.0	5.5	7.0	7.0	7.0
Low	Up Draft	Pilot No.	17	4	12	16	15	8	10	14	9	6	13	1	11	7	3	2	21
		Puff, in. H_2O	0.0	1.0	1.5	2.5	2.5	3.0	3.0	3.0	3.5	4.0	4.0	4.0	5.0	6.0	6.5	6.5	9.0
Medium	All Angles	Pilot No.	17	12	9	8	10	16	15	14	3	6	1	13	4	2	11	7	21
		Puff, in. H_2O	2.3	2.5	2.5	2.5	3.0	3.0	3.0	3.0	3.0	3.0	3.5	3.5	4.0	5.5	6.0	6.5	9.0
Medium	Down Draft	Pilot No.	17	12	9	10	14	8	3	16	4	13	6	15	1	2	7	11	21
		Puff, in. H_2O	2.3	2.5	2.5	3.0	3.0	3.0	3.5	3.5	3.5	3.5	4.0	4.0	4.0	5.5	7.0	7.5	9.5
Medium	Horiz. Draft	Pilot No.	17	12	3	16	6	1	9	10	8	14	4	15	13	11	2	7	21
		Puff, in. H_2O	2.5	2.5	3.0	3.0	3.0	3.5	3.5	3.5	4.0	4.0	4.0	4.0	4.0	6.0	7.0	9.0	9.0
Medium	Up Draft	Pilot No.	12	8	16	15	10	17	9	1	6	13	14	3	7	11	4	2	21
		Puff, in. H_2O	2.5	2.5	3.0	3.0	3.0	3.0	3.5	4.0	4.0	4.0	4.5	5.5	6.0	7.0	8.0	11.0	12.0
High	All Angles	Pilot No.	....	....	....	12	17	9	10	14	16	15	3	8	13	2	11	7	21
		Puff, in. H_2O				2.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.5	4.5	5.5	6.5	6.5	9.0
High	Down Draft	Pilot No.	....	....	....	12	17	9	10	14	3	8	16	15	13	2	7	11	21
		Puff, in. H_2O				2.5	3.0	3.0	3.0	3.0	3.0	4.0	4.0	4.0	5.0	5.5	8.5	9.0	10.0
High	Horiz. Draft	Pilot No.	....	....	....	12	17	9	3	10	16	8	14	15	13	11	7	21	2
		Puff, in. H_2O				2.5	3.0	3.0	3.0	3.5	3.5	4.0	4.0	4.5	4.5	6.5	8.0	9.5	10.5
High	Up Draft	Pilot No.	....	....	....	12	10	16	15	8	17	9	14	13	3	7	11	21	2
		Puff, in. H_2O				2.5	3.0	3.0	3.0	3.5	4.0	4.0	5.0	5.0	6.5	6.5	9.0	9.0	10.0



currents than is the gas consumption of the pilot, when the latter is greater than 0.6 cubic foot per hour.

Construction of Composite Pilot Light

The three best pilots, on the basis of resistance to puffs of air, were:

No. 11 (most resistant to down drafts)
No. 7 (most resistant to horizontal drafts)
No. 2 (most resistant to up drafts)

It was decided to combine in one composite pilot these features which appeared to make a pilot most resistant to down, horizontal, and up drafts. From inspection of the three best pilot lights above it was believed that the gas consumption should be greater than 0.6 cubic foot per hour, and that the following features were also significant:

1. To resist down drafts, the pilot should be of the Bunsen type. A hood over the top of the pilot seems necessary; the best shape for this is a cone as wide as practicable, extending at least ½ inch beyond the edge of the flame pillar. The flame ports should be horizontal. (See sketch, Pilot No. 11.)

2. To resist horizontal drafts, the pilot should be of the Bunsen type. The burner ports should be on opposite sides of the tube, so that those on one-half of the tube are on the lee side. The ports should be diagonally cut exactly as on Pilot No. 7 (*q.v.*) by sawing downward at a moderate angle on opposite faces of the burner head, which should be a ⅛-inch hexagonal pipe cap. The inlet tube conveying the air-gas mixture should extend inside the head above the ports, impinging closely upon the ceiling of the burner head. (See sketch, Pilot No. 7.)

3. To resist up drafts, the pilot should be of the Bunsen type; the burner ports should be horizontal; there should be a shield below the flame as on No. 11 and No. 2 (*q.v.*), preferably an inverted cone of the same diameter as the upper shield to withstand down drafts. The primary air ports should lie on a surface whose elements are vertical, *i.e.* the elements are parallel to the up draft of air. (See sketch, Pilot No. 2.)

A composite burner was constructed according to the findings summarized in the preceding three paragraphs. It is shown as No. 21 in the series of sketches. This pilot light actually did perform in a very superior manner relatively to the other pilots tested; almost without exception it was the most resistant of all to downward, horizontal, and upward puffs of air at any of the three gas pressures applied. In every case the resistance of this composite burner is in the high brackets (8- to 12-inch puff), although its gas consumption is moderate (0.72 cubic foot per hour at 6 inches). The poorer pilots, it will be noted, in many cases were blown out by puffs of 4 inches or less.

Since this new pilot, No. 21, appears more resistant than that one which our field men consider satisfactory, *viz.*, a Keystone slotted type, it should give in practical service much better performance than the latter. It is about two or three times as resistant to puffs of air as the other types listed here, no matter from what angle the puffs are applied.

This pilot is made of ordinary standard fittings, and by the choice of proper lengths it is adjustable so that the mixer may be removed from the hot zone. It is not suitable for range tops, nor is it perhaps a universal pilot; but its use for water heaters, floor furnaces, central furnaces, and the like would seem favorable.

Details of Composite Pilot No. 21 (See Sketch)

a. Standard ⅛-inch pipe nipple crimped on end, tipped for Loraine by-pass plug No. 16, 6/32-inch thread.
b. ⅛-inch pipe coupling; primary air ports drilled No. 3 M.T.D.
c. Loraine by-pass plug, drilled with No. 80, 79, or 78 M.T.D. These optional drilled plugs should be carried by the trouble men because of the difficulty of drilling such small sizes in the field.
d. Burner throat. Brass tubing threaded on outside with ⅛-inch pipe thread.
e. Lock nut.
f, h. Truncated conical shields.
g. Hexagonal ⅛-inch pipe cap with slots.

Independently of these experiments, C. E. White has developed a new pilot of radical design, with startling resistance to enormous puffs and drafts of air, literally impossible to blow out from any angle with the equipment now in hand. This pilot will be the subject of a report to be released at a later date.

Equipment and Methods for Gas Service Training

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Pacific Gas and Electric Company

IT IS the intent of this paper to discuss a method of instruction used in the Pacific Gas and Electric Co. in presenting an educational program for gas service men.

The advent of natural gas which broadened the field of gas utilization, the rapid development and frequent changes in the design of appliances, and the greater variety of equipment and controls being placed on the market had so complicated the service work that a definite program of instruction for all service men was undertaken. When this program was started the method of instruction which will be discussed had not been worked out. This method was developed as the result of the instructors' experiences in their endeavors to overcome certain difficulties encountered in the instruction of groups of men having a wide range of background.

A few of the men had academic training and could reason from cause to effect and vice versa. Many of the men had been engaged in service work for a number of years and had been quite efficient until the deluge hit them. Several of these men did not have an academic background but carried to the classroom mental processes, habits, and impressions acquired in the field through experience. While experience is sufficient and even supreme for many things, as a starting point for classroom instruction it presents a real problem for both the instructor and individual class member.

In a group trained through experience only, the mental characteristics and behaviors developed thereby are so varied that a class including such a group presents problems entirely different from those in ordinary classroom practice.

In the beginning of the service training, when the uninitiated instructor stepped into one of the classrooms, he was uncertain as to how to proceed. In the first place, he found it extremely difficult to get complete attention. In the second place, he was disconcerted by the fact that a few men were quite willing to absorb his complete time, without any thought of the balance of the class. Further, he was disturbed by the fact that the men seemed to have no idea of classroom decorum and while their intent was perfectly good, they did not hesitate to distract the attention of others by conversation and very likely by conversing on the very subject at hand. The instructor was appalled by the small degree of penetration of his previous text assignment. He was faced by the fixed and determined attitude in many of the men's minds that seemed to say—"If I had the problem on which you, Mr. Instructor, are endeavoring to question me, in some customer's basement on some appliances, I could do it but I cannot work it here." Lastly, the instructor was discouraged by the fact that men would rather spend considerable time "cutting and trying," hoping to get the proper effects, than to spend a few minutes analyzing the trouble.

The above conditions seriously weakened the instructor's presentation of the subject and distracted the class members. As a result the original method of teaching was revised to meet these difficulties. Solutions for them involved the development of a classroom procedure which has been found to be satisfactory.

The first principle discovered was the fact that it is necessary to challenge the class to do battle with the particular field problem on their own ground with their own weapons. The instructor must make his questions and tests conform to actual field problems and show that the solutions are the work that the service men must do in the field. In other words, the instructor must completely transport himself from the realm of the classroom to an actual field atmosphere. In the beginning, when simulating service troubles

on classroom equipment, gas tubes were stopped with wads of rags, contacts of electric controls were broken by the insertion of pieces of paper, and similar means of making apparatuses inoperative were used. The men objected at once, and complained that both the cause and effect so produced were artificial and not true to field conditions. The essence of the new method adopted is the use of actual service conditions in classroom work.

The first effect of the application of this principle is to eliminate at once from the students' minds any excuse for not understanding the work or for not being able to do the problem. Men take pride in their own particular craft and each feels that he is more or less a master in it and resents the inference that there is any problem in his daily work which he cannot meet. By fitting the educational procedure to the surroundings that are a part of their particular field activity they feel at home and realize their own responsibility to master the work. Here lies the reason for the extensive use of field equipment and practical conditions in gas service men's training.

The next principle adopted has to do with the first lesson on any given type or model of equipment. Some members of the class may feel they are quite well informed on it and treat the subject lightly. It is necessary to bring them out of this attitude at once. For instance, when controls are being studied one or more are set up in the classroom on a board in such a manner that they may be made to operate just as they do in the field. (See Fig. 4). Some problem of actual occurrence having to do with the performance of the control is given to the class. This problem must be practical and also one that is rather difficult; if possible, one that is known to be slightly beyond the ability of the class. This constitutes a direct challenge to all. It attracts attention, arouses interest, and eliminates the disturbance that might be caused by inattentive men who are too sure of themselves.

After the disposal of the first problem and while the attention is still centered upon the equipment, other problems are discussed that are of a similar but simpler nature, arranged in a systematic order so as to present a logical and complete picture of the fundamentals, construction details, and operation. During this period the student is instructed how to handle the equipment with his own hands. Cut-away models may also be used but only as aids in explaining the arrangement of parts and construction details. Occasionally, with auxiliary equipment which is necessary to make the classroom set-up on the board complete and workable, it is necessary to substitute a miniature device for the real thing. For example, the gas boiler mounted on the board for controls (Fig. 4) is not true to life, but insofar as the instruction on controls is concerned this does not seem to lessen the efficacy of the board for its purpose.

The use of the two basic principles, namely, first, making the performance practical and using actual equipment; second, the issuing of a practical challenge when beginning on each type of equipment, has accomplished much more than can be taught through the use of lecture, text, and quiz.

Of course, lectures, texts, and tests are used in conjunction with the problems on the apparatuses. A definite policy as to the use of the quiz has been adopted. It is used to force attention on the lectures and the material in the text; at each session there is a short written test based upon the previous lecture and the assigned text and, as occasion demands, it may include some of the problems on the equipment.

The realization on the student's part that before the session is over he will be required to demonstrate his ability in actual problems on practical equipment and to prove his knowledge of the material in the lecture and text, makes him feel that the three sources of information are all helps in meeting this "show down." With this favorable viewpoint he is led into an attempt to coordinate the information from his lecture notes and text with that obtained from the demonstrating board. They now mean something to him in a practical way. The problems for the quiz are not stereotyped nor artificial but are made up from time to time from unusual occurrences in the field or from questions raised during the discussion in the class.

Sometimes it is necessary to use diagrams in conjunction with the general procedure. For the purpose of illustrating the general procedure and the use of diagrams, the equipment used in training an electric gas-control circuit (Figs. 1, 2, 3, and 4) will be discussed. Figs. 5, 6, 7, and 8 constitute a parallel set-up for a gas-actuated control system.

The boards Nos. 1, 2, and 3 for both electric and gas and Nos. 5, 6, and 7 for gas-actuated control systems give the students something on which to build their conceptions.

Systems of electric controls are usually fabricated from control units, such as thermostats, low water cutoffs, steam pressure regulators, etc., most of whose electric terminals are coded by color. This color coding was done by the manufacturers with no thought that the colors themselves would lay out a wiring job for the gas service men, but rather that it would make simpler the tracing of circuits and the making of connections. Men have misinterpreted the manufacturers' intent and often depend strongly on the use of the colors. This weakness makes them particularly vulnerable

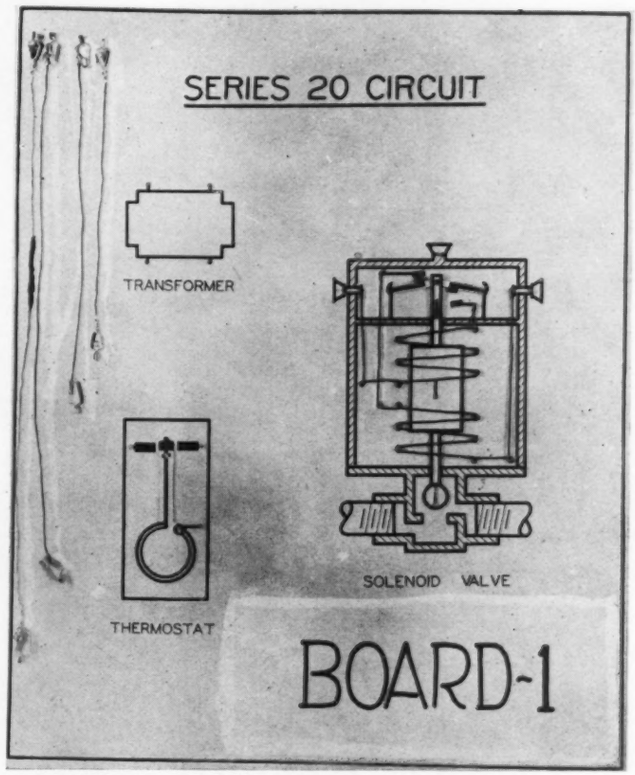


FIG. 1.

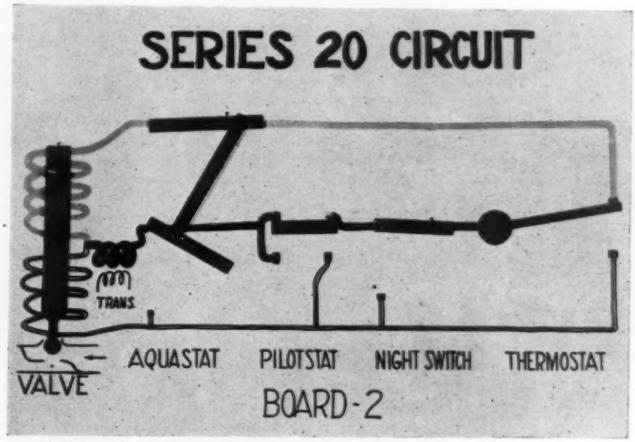


FIG. 2.

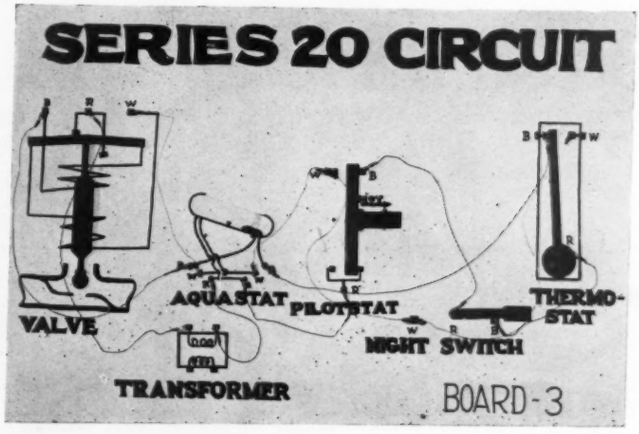


FIG. 3.

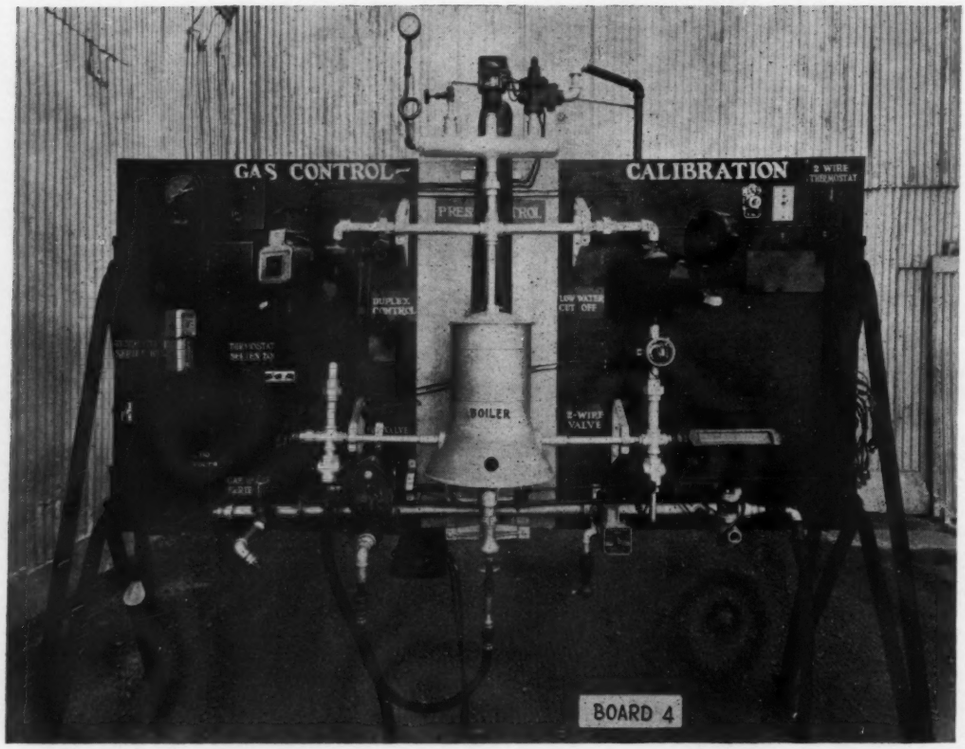


FIG. 4.

to a challenge which involves more in the matter of wiring than merely connecting red on red and white on white. This situation makes it simple for an instructor to throw out a challenge to the class to perform a particular wiring problem, as he may be quite positive that should the problem include any transposition of colors, most men will be in difficulties. They are in difficulties because it is either necessary for them to memorize the transposition in each particular case or make a diagram. The first is next to an impossibility and the second, the making of a diagram, has not yet been mastered. With these thoughts in mind, an instructor at the beginning of a class should request the wiring of a simple set-up, for example say, a thermostat, a pilotstat, and valve. To men who

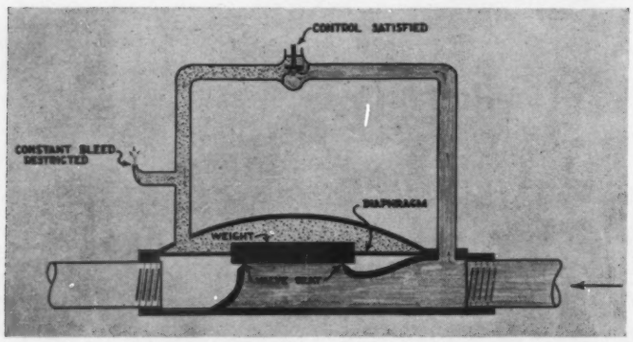


FIG. 5. Diaphragm gas control. (Board 1. Gas-actuated).

have never installed a pilotstat in this particular circuit the "cut-and-try" method is of little assistance, and they will realize that no matter where this problem had been presented, whether in a customer's basement or on the actual working board in the classroom, they would be unable to meet it. With men convinced by this means of their inability to do a simple, practical task, they are in a frame of mind most susceptible to an instructor's proposal of a method to help them over their difficulties. They have been challenged on their own ground, the controls on the control board before them are real controls using electric current to control gas exactly as done in the field. Further, they have been furnished their own weapons, the weapons in which they place so much confidence, the pliers and the screw driver, and they are convinced that there is something lacking in their knowledge, and that the problem proposed to them was fair and practical. So, at this point is sold an approach to any control problem as outlined and illustrated in Figs. 1 to 8.

After the challenge four steps follow in this method of presentation of this particular subject. The first step undertaken by the instructor is to assist the class to gain the ability to understand and manipulate a simple conventional diagram in its simplest form as illustrated in Figs. 1 and 5. These boards are both labeled "Board 1" as they are the first diagrams studied in either gas or electric control systems. In the case of the electric control system the board is fitted with brass binding posts on which removable conductors may be snapped, and the moving parts of the actual controls are represented by movable dummies. The students practice wiring on this valve and thermostat until they are thoroughly familiar with it. Second: A simplified conventional diagram, Board 2, Fig. 2 or Fig. 6, is used which includes a complete system of controls. Any control circuit may be conventionalized into a simple form which is a great deal easier to grasp than the picture form of diagram. This diagram is thoroughly discussed and studied. Third: Students next are led from a conventional diagram

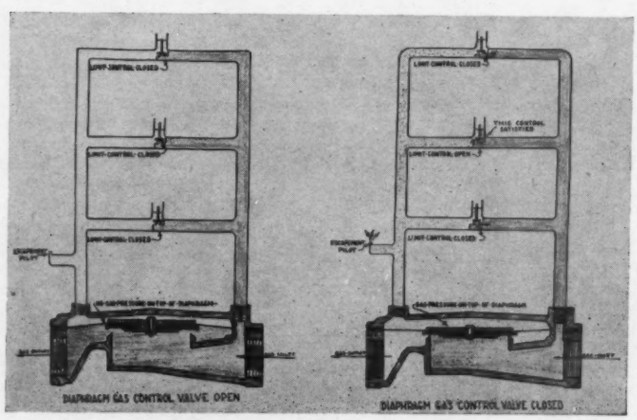


FIG. 6. Diaphragm gas controls. (Board 2. Gas-actuated).

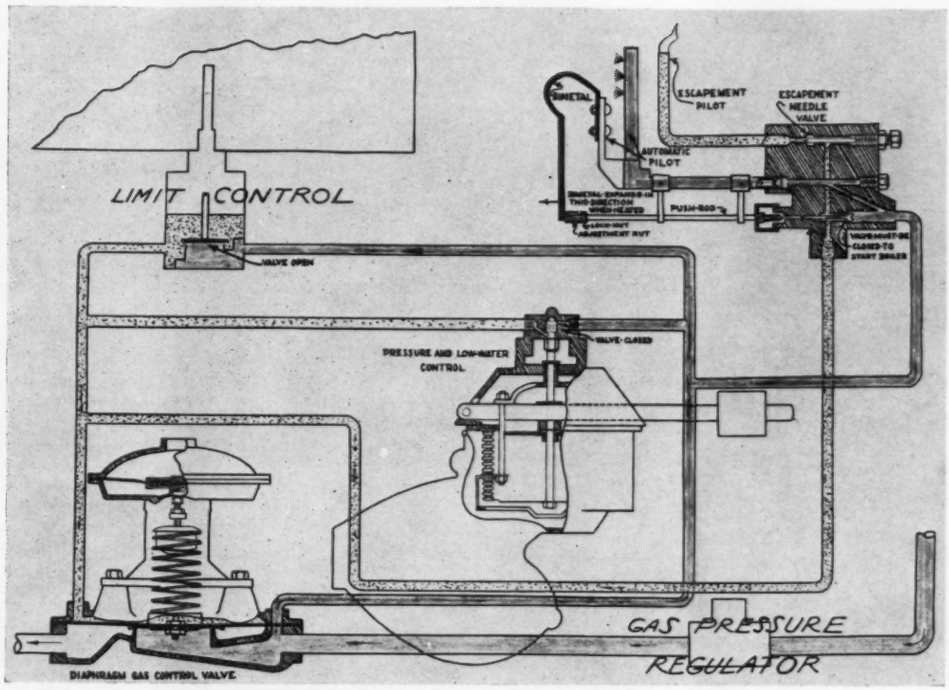


FIG. 7. Diaphragm gas controls. (Board 3. Gas-actuated).

to an animated picture diagram of the same system, Figs. 3 and 7. Fourth: The final step is the use of the diagram just shown for connection of the actual controls and valves on the board containing the real working equipment, Board 4, Figs. 4 and 8. The thinking is all done on the sketches and the wiring is done mechanically, checking off each connection on the sketch as it is completed on the board.

In gas control work, as in radio, after two or three units are added to a circuit it is practically impossible to carry sequences in one's mind and the diagram method is the only answer known for the difficulty. It is believed that the procedure of working with diagrams will convince students of the superiority of this system over "cut-and-try" methods.

To summarize the equipment to fit any lesson to be taught by this method it is necessary to furnish: (1) A sample of the equipment in working condition on which the students' knowledge can be tested, (2) a board carrying an animated diagram covering the fundamentals of the units or system being studied, (3) a board carrying a conventionalized diagram in animated form covering the general principle expanded to its widest use, (4) a board carrying an animated diagram in picture form of a special application of the system.

Both the challenge and the written quiz stimulate careful reading of the text by the students and crystallize their questions and conceptions of the different subjects. A written quiz on the assigned text for the current lesson is given at the beginning of each class period. After the first lesson men anticipate the quiz and that, together with the fact that they will be tested in a practical way on the apparatus covered by the quiz, makes them feel a heavy responsibility to be able to answer all questions. It is true that most students have difficulty retaining what they have read. The quiz is quite generally used in all types of instruction to demonstrate to students that simple questions of their own making can be used during study to check themselves as to their absorption of the subject matter. The inability of students to readily absorb thoughts from printed matter may also extend to the spoken word. The sincerity of the instructor cannot overcome this weakness of students. He may have an intensive interest in his subject and an earnest intent to put over his points, but has no leverage with which to impress his students and to cause them to absorb the material. For this reason the simple lecture method alone is weak.

While the keynote of the training as given by this method is practical and covers actual problems at hand, the training in the use of fundamentals enables students to project themselves farther than practical experience alone could lead them. A man who knows only sufficient to manually do his job is not trained. First, he cannot explain situations to anyone else. Second, his ability will be limited to the capacity of his memory. Third, his job tomorrow will be vastly different and more complex than today. This method prepares him for tomorrow by teaching the student correct thinking and fundamentals.

It is believed that the day of training gas service men by placing them on a truck with an "old timer" is gone. It is gone because most "old timers" are usually not our best service men on our newer controls. It is gone because this method of training is haphazard and depends on the type of work to which the particular service man is assigned. It is not sufficiently inclusive to cover all types and classes of appliances. It is gone because the gas service men's daily work is becoming a very complex duty due to the introduction of elaborate systems of automatic control. As gas utilization becomes more involved, a broader and wider application will be made of equipment in training and a closer tie-in with fundamental principles and more general understanding of such aids as diagrams and charts will be necessary.

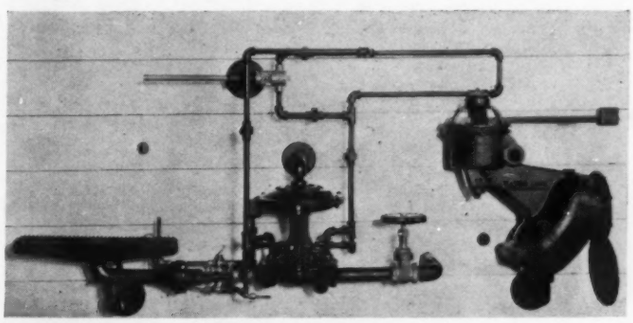


FIG. 8. Board 4.

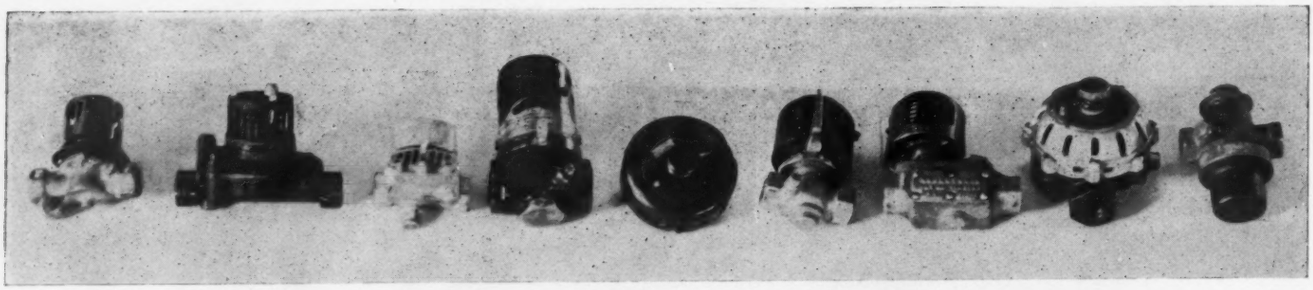


FIG. 1.

Thermostats for Gas Space Heaters*

INTRODUCTION†

MANY homes on the Pacific Coast, especially in California, are heated either with small circulators or radiant type heaters, as there are no extremes of low temperature to contend with. The average temperature in Southern California for 1935 was 63.5° with the thermometer rarely dropping below freezing. In this day of increasing application of automatic temperature control it is natural that thermostats have become available for the circulator type of heating. Heretofore, the thermostat as applied to a space heater, has been non-existant and is, therefore, a comparatively recent development in the gas industry and one which probably will assume considerable importance within the next few years.

A review of all available sources show that there has been no published information on this subject, other than manufacturers' literature. It is our opinion that to date most of our present practices, due to the lack of authentic data, have been based on manufacturers' tests and literature and our own meager experiences in the field. Therefore, after a survey of the available field experiences and present practice, it was found impractical to reach a logical conclusion, as far as any standard practice or uniform procedure was concerned. Hence, it was decided to augment actual field experiences with specialized tests.

Thermostats Available for Consideration

A request was made to manufacturers to submit thermostats suitable for space heater use, either as a built-in control or, as designed for attachment to the inlet piping of a heater already in service which had not been designed originally for thermostatic use. In answer to this request we received a great number of thermostats, both electrically operated and gas actuated. From these, nine were chosen and are shown in Fig. 1. Those chosen were considered most suitable for use on space heaters and were small, compact and mechanically operated. No electrically operated types were selected as, in most cases, they were complicated. Also, in many cases, the electrical devices required permanent installation in one location, whereas the committee preferred either compact thermostats that could be built into the heater or attached to the inlet piping which, if need be, could be moved with the heater to various rooms without damage or bother of removing parts from the wall.

Operating Data of Selected Thermostats

The data given in Table No. 1 pertain to the types under consideration and will serve as a tabular reference of their different actions. All of these thermostats are available on the market and appear to be well constructed. While it is desirable that they be installed by the manufacturer of space heaters as an integral part of the appliance, they perform very satisfactorily when added, as an auxiliary, to an appliance already constructed, especially if a few simple precautions as to placement in the line, etc., are observed. The prices as of December, 1935, ranged from $4.00 to $15.00 retail.

Leakage From Valve Body and Joints to the Atmosphere

Leakage occurred in three of the thermostats when a pressure of ½ pound per square inch was applied at the inlet connection. On two of the thermostats the leakage occurred in each instance at some point which originally could have been made gas-tight easily by the use of cock grease or, in the case of one thermostat, by more care in assembly. It is possible for leakage to occur in the gland pins of thermostats C, D, F, G. This can be corrected by the use of a small amount of grease on the gland pin. Thermostats A, E, and H are actuated through a gas-tight metal diaphragm. Thermostat B is controlled by a diaphragm valve with no packing gland to leak.

Leakage Through Thermostatic Valve in Closed Position

Three of the nine thermostats permitted gas to pass by the thermostatic valve when the valve was in "closed" position when a pressure of ½ pound per square inch was applied at the inlet connection. This was not considered dangerous for, in all cases, a slight grinding of the valve faces stopped the leak and, in addition all three leaking thermostats had a minimum bypass adjustment, which allowed gas for a minimum flame. It is believed that the A.G.A. specifications should be strictly adhered to in the case of valve leaks, as many thermostats will be operated on a pilot flame and in this case should be completely gas-tight when off. Both snap-action thermostats showed good shut-offs on this test.

Temperature Dial Checks

Five thermostats were not provided with temperature markings but were marked "normal", "hot", and "cold" with lesser graduations which, according to instruction pamphlets, represented various ranges from 1 to 4 degrees per division or overall temperature ranges of from 20 to 40 degrees F. The dials of the remaining four had actual temperature markings ranging from 40 to 80 degrees F., by degrees.

Dial marking tests of the various thermostats indicated quite accurate dial calibration. Absolute accuracy is not required, since it is not warranted by the type of service. A tolerance of plus or minus 3 degrees F. at the extreme dial markings after accurate adjustment at the midpoint, or 70° marking, should be satisfactory.

From a service point of view, thermostats without actual temperature markings in degrees are to be preferred, as actual temperature markings afford an opportunity to the customer to check the thermostat dial with a thermometer held at the thermostat, and to make an unwarranted call to the utility company when the room temperature does not exactly follow the thermostat dial temperature.

Explanation of Operation and Applications, and Discussion of Probable Service Problems

The following photographs, diagrams and discussions will explain several typical space heater thermostats and their operation. Also, short notes are included on possible service problems which might be encountered on each.

Snap Action Thermostat—Diaphragm Controlled Valve

The essential parts of this thermostat are the bi-metal disc (G), and bleeder valve (E), and the diaphragm valve (M) as shown in Fig. 2. The temperature responding element of this thermostat is the snap disc (G).

Operation: The operation of the diaphragm (M) is controlled by the difference in gas pressure between the lower diaphragm chamber (A) and the upper chamber (D). The valve closes by dead weight when the pressure in the two chambers is equal. The pressure in the chamber (A) is practically constant, being the inlet line pressure, while the pressure in the upper chamber (D) is controlled by the small bleeder valve (E), which in turn is operated by the snap-acting disc (G). Room temperature affects this disc in such a manner that when the room temperature reaches the thermostat setting, the disc snaps downward, carrying the bleeder valve to the seat

* Committee Report: T. G. Wallace, L. A. G. & E. Corp., chairman; A. E. Finlay, Portland G. & C. Co.; H. W. Geyer, So. Counties Gas Co.; R. T. Richards, Cent. Ariz. Light & Power Co.; M. A. Richford, P. G. & E. Co.; R. I. Snyder, L. A. G & E. Corp.

† Submitted by T. G. Wallace, Los Angeles Gas and Electric Corp.

(K). With the bleeder valve in this position, the gas which enters the upper diaphragm chamber (D) by the needle valve (C) is prevented from escaping through the bleeder valve and a pressure is built up on top of the diaphragm equal to the pressure below, and the main valve closes, due to the weight (M).

A drop in the room temperature causes the disc to snap upward, carrying the bleeder valve to its upper seat (H), and opening the upper diaphragm chamber to the escapement line (N). This reduces the pressure on the top of the diaphragm and allows the pressure on the lower side to overcome the weight (M), opening the main valve and allowing gas to flow to the burner.

It will be noted that if the thermostat unit and the diaphragm valve were separated at the gasket L, the operation would still continue as before if tubing connections were properly made between these two units. This is exactly what is done in the remote control unit in which the thermostat unit is arranged for wall mounting or mounting on the front or side of a space heater; in fact, it can be mounted at any point remote from the diaphragm valve and connected to it with small copper or aluminum tubing.

The scale for pointer (F) is divided into 20 equal divisions and represents a temperature range from 40-80°F. No temperatures are marked on the scale. The extremes of the scale are marked "High" and "Low".

Servicing: This snap-action thermostat should be comparatively free from servicing, as the main valve has a soft valve seat resistant to leakage, and is not easily held open by dust or scale.

The bleeder valve has a metal-to-metal seat. The use of the upper valve and its positive snap action seat (H) prevents gas leakage by the stem when gas is flowing out the escapement line (N). The bleeder valve and thermostatic element can be removed by simply unscrewing the entire top part which will come off as a unit, providing an easy method for cleaning the valve. Inspection of the main valve or diaphragm is made by removing the screws at the top and bottom of the diaphragm casting. It is not necessary to disturb the piping.

Throttling Thermostat—Wafer-Bellows Controlled

The operation of this wafer type throttling thermostat (Fig. 3) is quite simple. As the room temperature rises, the throttling action of the valve (5) gradually reduces the amount of gas supplied to the burner, by the expansion of the wafer bellows (1). As room temperature falls below the set point, the valve (5) opens gradually, from contraction of the wafer bellows, increasing the amount of gas supplied to the burner. The use of the diaphragm between the valve and thermostatic wafer seals the gas compartment and eliminates the need of a packing gland. The only possibility of leak is by fracture of the metal diaphragm. This thermostat is regulated by the knurled knob and pointer (2). The pilot light is turned on or off by a built-in pilot valve on the side of the thermostat. Bypass adjustment (7) is for heaters not equipped with pilot light. To adjust the minimum burner flame, the indicator (2) is turned to the right until the burner flame goes completely out, then screw cap is

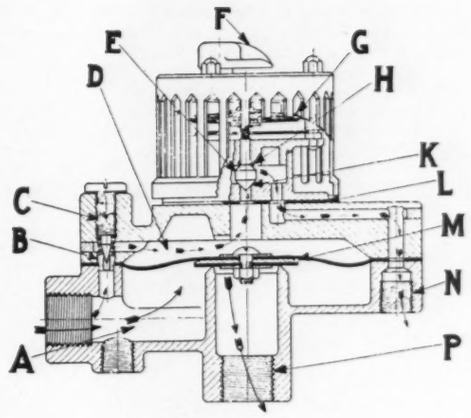


FIG. 2.

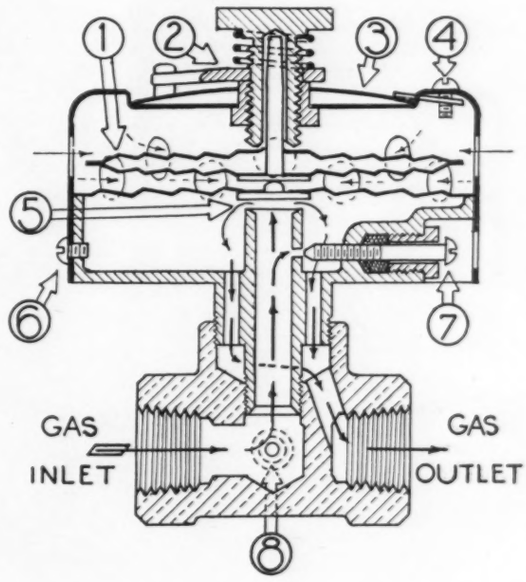


FIG. 3.

TABLE NO. 1.

Make	Size (Inches)	Snap Action or Throttling Type	Graduation of Dial	Adjustment of By-pass	By-pass Adjustment Sealed in Body by Screw Cap	Bellows Bi-metal Etc.	Packing Gland on Action	Actuated With Metal Diaphragm	Body Metal	Sensitivity °F.*
A	½	Throttling	Cool Normal Warmer	Needle Valve	Yes	Sylphon Bellows	.....	Yes	Brass	2.0
B	½	Snap	Low Normal High	Needle Valve	Yes	Metal Snap	Bleed to Leather Diaphragm	.....	Pot Metal	2.5
C	⅜	Semi-throttling	Cool Warm	Needle Valve	Yes	Bi-metal Curled Strip	Yes	.....	Pot Metal	1.0
D	¾	Throttling	Cool Normal	Needle Valve	Yes	Bellows	Greased Rod	.....	Brass	2.0
E	½	Throttling	45-82 in Degrees	Needle Valve	Yes	Single Bellows	.....	Yes	Brass	1.0
F	½	Throttling	60-80 in Degrees	Slot Orifice	Yes	Sylphon Bellows	Greased Rod	.....	Brass	1.5
G	½	Snap	60-80 in Degrees	Slot Orifice	Yes	Metal Snap	Greased Rod	.....	Brass	3.0
H	½	Throttling	40-80 in Degrees	Needle Valve	Yes	Wafer Bellows	None	Yes	Iron and Aluminum	2.0
I	½	Throttling	1-5 Graduations	Needle Valve	Yes	Bellows	None	Body Sealed	Brass	1.5

* Results of Mr. Snyder's tests described in third section of this committee report.

removed and bypass screw (7) is loosened. The burner is then lit and adjusted to the lowest point at which the burner will remain burning without danger of back-firing or extinguishing.

Servicing: The upper housing can be readily taken off by removing the screws (6) but if dirt or scale is securely lodged on the valve face (5) the diaphragm must be unsoldered to, reach it, which is not easily accomplished in the field.

Throttling Thermostat—Bellows Controlled, Using Valve Rod Action

Fig. 4 is a photograph of cover, bellows and heavy valve casing showing valve rod and self-aligning valve. The parts are made of heavy brass and are rugged and serviceable.

Servicing: The thermostat is easily serviced. The valve can be removed by simply unscrewing the brass plug in the bottom of the casting.

Throttling Thermostat—Direct Action

The thermostat of Fig. 5 is a throttling type. The temperature responding element is the hollow vapor-filled disc whose expansive and contractive movements from temperature changes are transmitted to the valve disc, which is held in place and centered over the brass seat by the leather diaphragm. The leather diaphragm, made from specially treated leather, is very durable and flexible and also serves to separate the gas and disc chambers, thereby preventing gas leakage.

Servicing: The valve and seat can be reached for servicing by removing the body screws (not shown in cross section), allowing the parts to separate at the diaphragm. This servicing can be readily done in the field with a screw driver for a tool.

Adaptation of Thermostats to Space Heaters

Figs. 6, 7, and 8 illustrate typical applications of direct acting thermostats to typical circulating heaters.

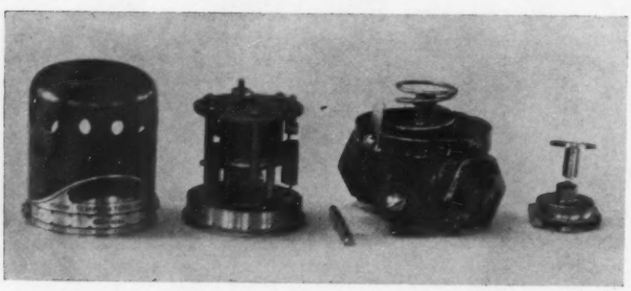


FIG. 4.

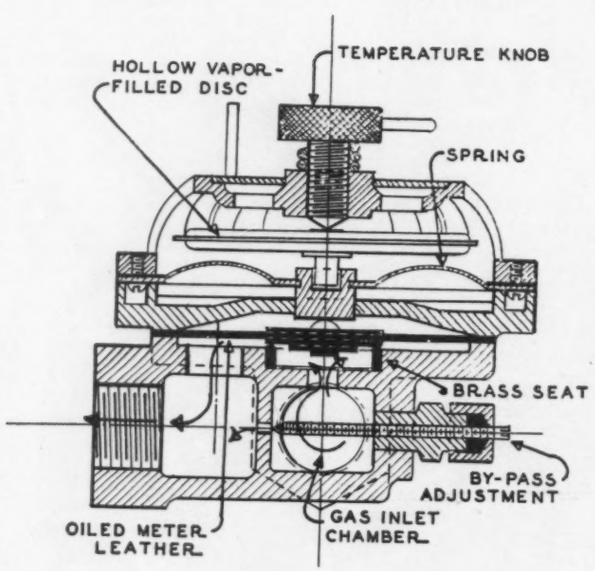


FIG. 5.

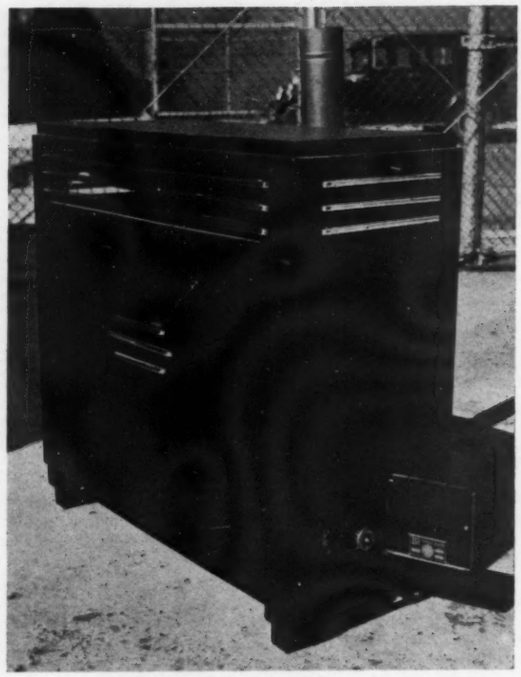


FIG. 6.

The thermostat of Fig. 6 is a throttling type control located in the gas line ahead of the burner. It is accessible through the burner valve door for adjustment by the customer.

The thermostat of Fig. 7 is a snap action type employing a diaphragm valve actuated by gas pressure. The diaphragm valve is located within the door.

The thermostat can be located at any convenient point, either on the shell of the heater as illustrated or on a remote wall. The diaphragm valve and thermostat are interconnected by two small gas lines of copper tubing.

Performance and Characteristics of Thermostatically-Controlled Space Heaters

Fig. 9 shows a typical temperature chart from a room heated by a circulating heater having a built-in throttling type thermostat as shown in Fig. 6. For the test, the bulb of a recording thermometer was placed inside and adjacent to the thermostat element to record changes of temperature reaching this element. This temperature is shown by the solid line in Fig. 9, holding approximately 80° F. throughout the test of 24 hours. A second recording thermometer was placed at the 4-foot level about 12 feet from the heater to record the average room temperature. This is shown by the middle or circle dash line in Fig. 9. The thermostat was calibrated to hold a 70° F. room temperature, and, as will be seen, this temperature was held practically uniform during the test. The outside atmospheric temperature is shown by the dotted line.

Discussion of Temperature Setting to Provide Maximum Comfort, and Allowable Fluctuation Before This Comfort Is Disturbed.

There seems to be a great difference of opinion as to what constitutes proper or improper temperature regulation, or the variation of room temperature that can be tolerated without a sense of discomfort to the occupant. We can settle this question to our satisfaction by reference to the Medical fraternity, in the study of metabolism. The answer given is as follows: Where the relative humidity is fairly constant and at a reasonable percentage (40 per cent is generally conceded to be the healthful average at which the body temperature control system and the nose air conditioning mechanisms function best). The normal human body is capable of detecting a temperature change of from 2 to 3 degrees around this 70 degree average, if the change occurs in a short period of time; such a change produces no discomfort.

Therefore, temperature regulation within reasonably narrow limits, "say 3 degrees", and uniform heat distribution are essential to assure the greatest comfort.. This must be accomplished without effort or undue attention on the part of the occupant for convenience. It is agreed then, that when we attain all of these desirable conditions we have modern thermostatic control, and as gas is the

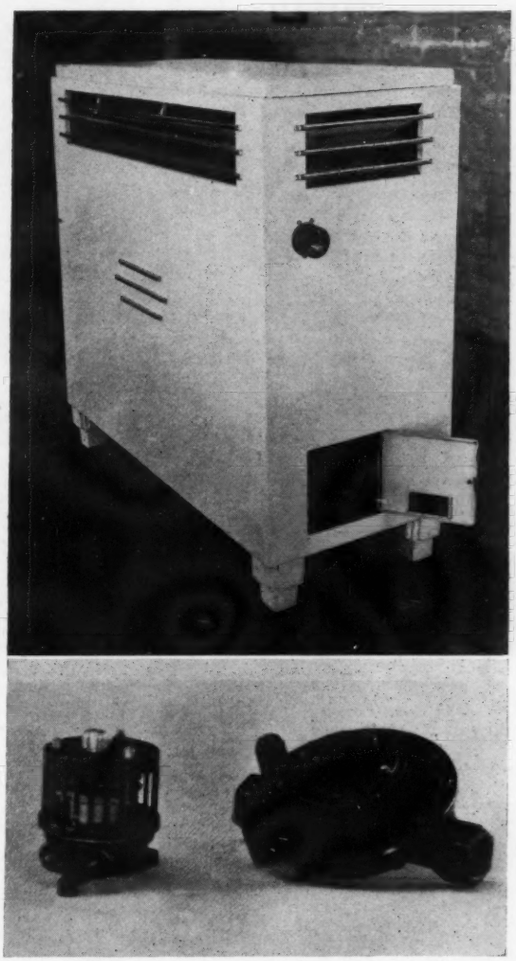


FIG. 7.

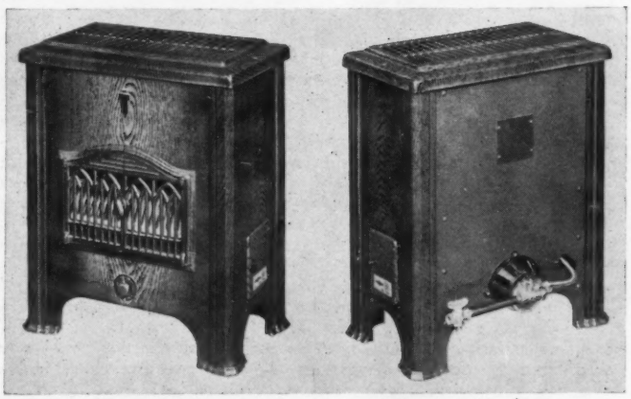


FIG. 8. Thermostat placed in back of the heater with dial control mounted in front for convenience in setting.

logical and most economical fuel for heating, it is the problem of the utility to foster an inexpensive and serviceable thermostat to meet these demands.

It is still undecided which type of thermostat, the snap-action, or the throttling-type, more closely fits the problem. Our tests to date have shown both to be very efficient and both held the temperatures well within the specified limits.

Conclusions

The problem of space heating control is not one of developing a more sensitive thermostat, but rather the development of a thermostat that can be sold at a figure comparable to the cost of a heater. It will be realized that the additional cost of the thermostat over and above that of the space heater makes it rather difficult to promote the idea of temperature control on individual space heaters. One of the thermostats listed retailed for nearly as much as the space heater on which it was tested.

The utilities and heater manufacturers realize the potent appeal and advertising value of this control, but are held back by the high original cost.

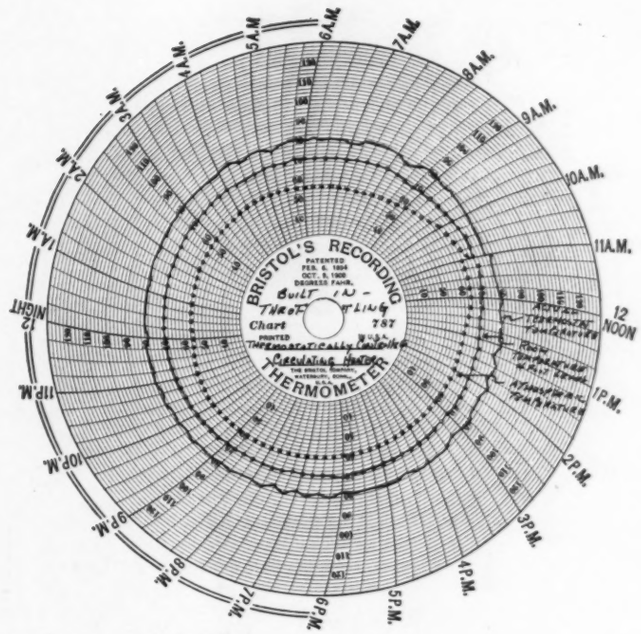


FIG. 9. Twenty-four hour temperature chart from built-in throttling type thermostat in a typical room.

INSTALLATION RECOMMENDATIONS AND OPERATION OF A DIRECT ACTING TYPE THERMOSTAT FOR USE WITH GAS-BURNING ROOM CIRCULATORS*

Following a few installations of a direct acting type thermostat, employing a liquid filled sylphon bellows for the temperature responding element, service reports were received that in some instances the thermostats failed to regulate room temperature in that they did not reduce to the minimum bypass flame during an excessive rise in room temperature. Since there was considerable uncertainty concerning the operation, adjustment and proper location of the control, tests were made with the thermostat and a current model, gas-designed room circulator to determine the effect of locating the thermostat at different points with respect to the heater, the quality of temperature regulation that could be expected, and the means of adjustment.

A section view of the direct acting thermostat is shown in Fig. 10. It is intended for installation close to the heater in the gas service line to the heater. Regulation of room temperature is obtained by control of gas flow to the heater by the expansive or contractive action of the sylphon bellows on the valve disc during temperature changes. A bypass adjustment is provided for a minimum flame.

Thermostat Calibration and Adjustment:

When set at "Normal" position the thermostat should reduce gas flow to maintain a temperature in the range of 69-73° F. If it is appreciably above or below these temperatures the control can be recalibrated by turning adjustment screw clockwise to lower the temperature and counterclockwise to raise.

Failure of the thermostat to shut off when room temperature is high when operated for the first time may be due to the stiffness of the moving parts. This may be remedied as follows: Without dis-

* Submitted by M. A. Richford, Pacific Gas and Electric Co.

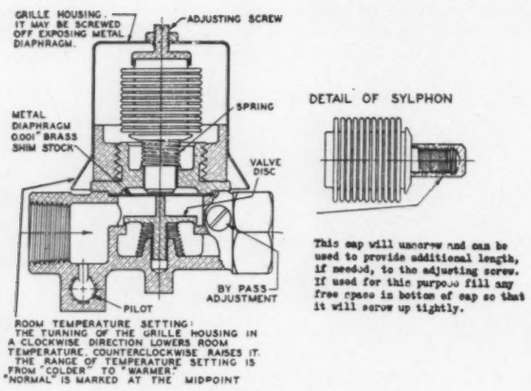

GRILLE HOUSING. IT MAY BE SCREWED OFF EXPOSING METAL DIAPHRAGM.
ADJUSTING SCREW
SPRING
METAL DIAPHRAGM .001" BRASS SHIM STOCK
VALVE DISC
BY PASS ADJUSTMENT
PILOT
ROOM TEMPERATURE SETTING: THE TURNING OF THE GRILLE HOUSING IN A CLOCKWISE DIRECTION LOWERS ROOM TEMPERATURE. COUNTERCLOCKWISE RAISES IT. THE RANGE OF TEMPERATURE SETTING IS FROM "COLDER" TO "WARMER." "NORMAL" IS MARKED AT THE MIDPOINT
DETAIL OF SYLPHON
This cap will unscrew and can be used to provide additional length, if needed, to the adjusting screw. If used for this purpose fill any free space in bottom of cap so that it will screw up tightly.

FIG. 10.

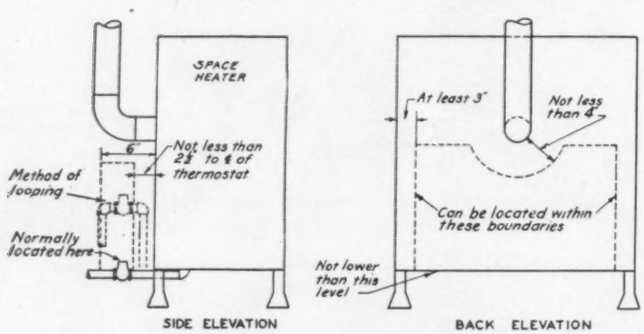


FIG. 11. Positions for location of direct-acting type thermostat for room circulating heaters—for room installation or when circulator is installed at least 6 inches out from the fireplace.

turbing the adjusting screw rotate the grille housing from "warmer" to "colder" a number of times. If it still does not shut off loosen the stop screw and turn grille housing in a clockwise direction one or more times beyond "colder". If it now shuts off return the housing to its original position and readjust with adjusting screw. If it still does not shut off a damaged valve seat or too high a minimum flame adjustment is indicated.

Summary of Test Results

Two of the three thermostats used in the test work were fully throttling in their action. The third varied between throttling and an almost "full on" or "full off" operation, depending upon whether the heat input requirements of the room were large or small.

The temperature differential of the thermostat between the valve positions of closed and full open is in the neighborhood of 10-12° F. Although the lag of the control is large, remarkably uniform temperatures will be obtained in the room providing the thermostat's location is proper and the heater has sufficient capacity.

The thermostat should not be located too near to the floor. Its location there may place it in the flow of cold air that is constantly returning to the heater; this current of air changes very little in temperature during cycles and tends to cause the control to be sluggish or inoperative. The lowest position that the control may be placed with respect to the floor is not definitely known and will probably vary in each case. Whether the control is to operate above a floor with an unheated basement below or on a second floor over heated rooms will affect the distance it should be located above the floor. The lowest position, and one that should be applicable to all installations, is where the flared part of the grilled housing, containing the graduations from "colder" to "warmer," is on about the same level as the bottom sheet of the circulator.

In general, satisfactory temperature control will be obtained in the majority of cases if the thermostat is located anywhere within the boundaries outlined in Figure 11. If, after installation, room temperature is too high and the thermostat will not shut off proceed as follows: (1) Refer to "Thermostat Calibration and Adjustment", above, and use the instructions given therein. (2) If these directions are inadequate, or the control is sluggish in action, failure may be caused by a location too close to the floor or to a brick facing or hearth of a fireplace. Elevate the thermostat or move closer to the back sheet of the circulator or to the side sheet if mounted on the side. These changes in position will place the thermostat in a zone of higher and more frequently changing temperature.

The effect of raising the thermostat to greater heights above the floor is to cause the control to become "full on" or "full off" in operation and to perform a greater number of operating cycles per unit of time. Thus the closer the control is located to the vent the more pronuonced will be the "full on" or "full off" operation. The farther the thermostat is from the vent the more the action changes to throttling with fewer "full on" and "full off" operations per unit of time. Either type of action will afford close temperature control providing the control location is kept out of the cold stratum of air near the floor.

The effect of locating the thermostat at higher levels is to expose it to radiant heat from the side sheets of the heater and the vent pipe. The temperature changes are more rapid in these zones and will cause the control to become "full on" and "full off" in operation. The temperature not only rises rapidly when the heater is operating but also falls rapidly when it is off. The overall effect is similar to the heat accelerating principle that is used in electric thermostats whereby auxiliary heat is added to the thermostatic element, causing the heating system to operate with more and shorter cycles per unit of time.

If the thermostat is placed so close to a fireplace as to leave insufficient space in the rear, it will be necessary to locate it at the heater's side. Limitations concerning this location have not been determined, but, in general, work so far completed indicates that for side mounting the thermostat should not be located lower than the level shown on Fig. 11 nor more than about 2½ inches out from the side sheet of the circulator (distance measured to the center line of the thermostat).

The thermostat may be placed with the axis of the bellows either vertically or horizontally. Substantially the same degree of regulation will be obtained with either mounting.

TEMPERATURE FLUCTUATIONS IN THERMOSTATICALLY CONTROLLED ROOMS HEATED WITH CIRCULATING OR RADIANT TYPE GAS SPACE HEATERS*

Thermostats were mounted approximately 4 feet in front of a radiant fire heater, the gas supply to which passed through the thermostats. A recording pressure gauge was located between the thermostat and the heater so that any action of the thermostat would be instantly indicated on the chart. Two recording thermometer bulbs were placed at the thermostat so that the temperature changes could be recorded and compared with the pressure chart to tie in temperature variation with thermostat action. Because of the varied pressure drop through the set-up and the maintenance of a minimum flame on the heater at all times, the actual pressure indication was meaningless, but any increase or decrease in pressure was due to thermostat action and so the time at which the change occurred was compared with actual temperature fluctuations. Because of the effect of the sun's heat on the test equipment, through the windows or metal roof of the test room, it was felt that the most valuable information could be obtained at night when a nearly constant outside temperature was maintained.

The nine thermostats used in the investigation are the same as those described by Mr. Wallace in the beginning of this committee's report. Each was allowed to operate over a period of several nights with various adjustments in order to be sure that representative operation was obtained. Fig. 12 illustrates the action of the various thermostats tested. The portions of charts shown were taken from the actual tests conducted. The pressure chart which is the lower curve in each case is cut out and superimposed on the temperature chart. The same time portion of each chart was taken and therefore the pressure indication on the lower curve corresponds exactly with the temperature immediately above it. The magnitude of the pressure, as explained before, is not important, as the chart merely shows whether the thermostat was in the "on" or "off" or some intermediate position at any given time. It will be noted that, with the exception of thermostat A, which is, strangely enough, a throttling type, a definite identifying form of pressure curve was obtained for the snap-action types and for the throttling types. In the case of thermostat A, very sensitive actuation of the valve was found, resulting in operation very similar to the snap-action type. The valve seemed to crack wide enough to permit a full flow of gas in all open positions and did not throttle through any intermediate positions. However, as may be seen, it maintained unusually constant temperature variations through all of the cycles. Because of the shortness of the cycles and the lag in the recording

* Submitted by R. I. Snyder, Los Angeles Gas & Electric Corp.

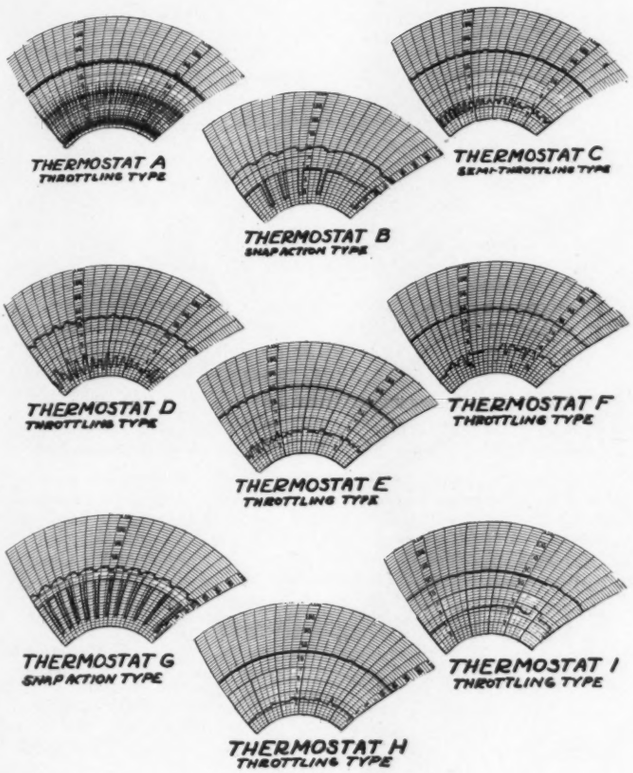


FIG. 12.

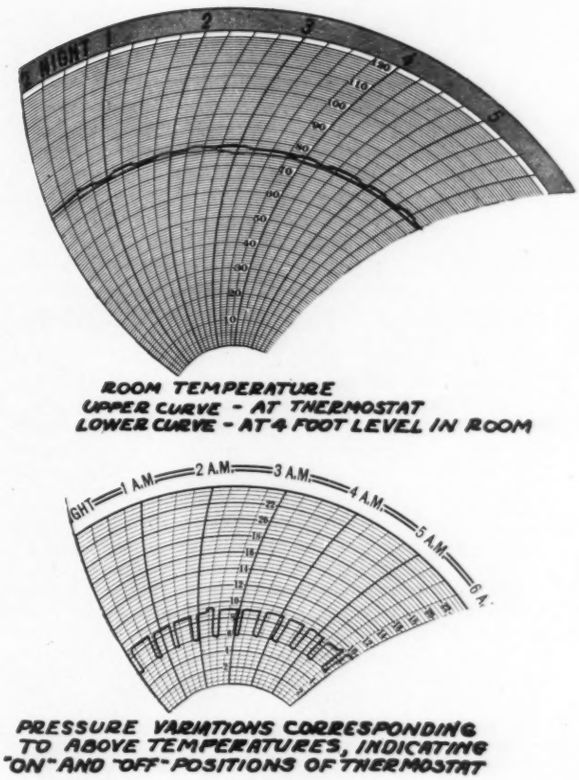

NIGHT
ROOM TEMPERATURE
UPPER CURVE - AT THERMOSTAT
LOWER CURVE - AT 4 FOOT LEVEL IN ROOM
1 A.M.
2 A.M.
3 A.M.
4 A.M.
5 A.M.
PRESSURE VARIATIONS CORRESPONDING TO ABOVE TEMPERATURES, INDICATING "ON" AND "OFF" POSITIONS OF THERMOSTAT

FIG. 13.

thermometer it is possible that a greater variation than is indicated existed.

The average sensitivities of the various thermostats are listed, for convenience, in Table No. 1 of this committee's report.

It may be seen that the maximum spread found on any of the thermostats studied was 3 degrees, as measured by the recording thermometer. These temperatures were taken at the thermostat element and should vary more than average room temperature.

In order to identify temperature at the thermostat with average room temperature, another test was made. A large gas space heater of the circulating type was installed in the test room with provision for the various thermostats to be connected in the line supplying gas to the heater. One double pen recorder was placed so that one bulb indicated the temperature at the thermostat while the other indicated a room temperature at the 4-foot level. Two other recorders were used, one indicating another 4-foot level room temperature and the other a temperature at the level at which the thermostat was placed, but in another part of the room. In these tests the whole room had to be heated, hence the cycles of operation of the thermostat were further apart and by comparing the sensitivity found in the previous tests a definite relationship could be established between temperature at the thermostat and average room temperature. The results of the second portion of the investigation are tabulated in Table No. 2.

The above temperatures are average figures taken from the recording thermometer charts. The "on" and "off" columns refer to the temperature corresponding to a change in pressure on the recording pressue gauge which would indicate some action of the thermostat. In general the temperature variation is less with the throttling type.

A further test was conducted using a large heater coming equipped with a snap-action thermostat. The thermostat similar to B was of the remote control type with the thermostat element located on the outer shell of the heater with the diaphragm valve connected in the piping to the burner. Fig. 13 illustrates the results of this test. In the upper chart, the upper curve indicates the temperature at the element showing the fluctuations necessary to actuate the device. The lower curve in the upper chart is the room temperature at a 4-foot level showing no appreciable effect or fluctuation reflected from the variation at the element. The lower chart illustrates the "on" or "off" positions of the thermostat and at any given time, as indicated on the charts, will correspond to the temperatures on the other curves.

It may be seen from the foregoing data that modern space heater thermostats are quite satisfactory from the standpoint of sensitivity, being sensitive to temperature changes of from 1 to 3 degrees, as indicated on a recording thermometer. Because of the slight lag in registering temperature indications the actual temperature varia-

TABLE NO. 2. RELATIONSHIP BETWEEN ROOM TEMPERATURE AND TEMPERATURE AT THE THERMOSTAT ELEMENT.

Thermostat	Temperature at Element (°F.)		Temperature at Other Part of Room at Element Level		Temperature at 4-Foot Level Station 1		Temperature at 4-Foot Level Station 2	
	On	Off	On	Off	On	Off	On	Off
A	71.5	74.0	70.5	75.0	73.5	79.0	72.0	76.5
B	72.5	73.0	73.5	73.5	74.5	75.0	74.5	75.0
C	72.0	74.5	71.0	71.5	73.5	76.0	73.0	75.5
D	72.5	72.5	74.0	74.0	75.0	75.0	71.0	71.0
E	71.0	72.0	70.0	70.0	73.0	73.0	74.5	74.5
F	70.5	70.6	71.0	71.0	74.0	74.0	74.0	74.0
G	71.0	73.0	70.5	73.5	74.0	79.5	72.5	78.5
H	69.5	71.0	70.0	71.0	71.0	71.5	70.5	72.0
I	70.5	70.5	71.0	71.0	72.5	72.5	73.0	73.0

tion might be slightly greater. Further, it has been pointed out that variation in temperature at the sensitive element of the thermostats does not reflect to any great extent in the average temperature of a room heated by thermostatically controlled gas space heating equipment. Of course, this performance is entirely dependent on the proper selection of heating equipment to perform the heating job in the desired room.

Leaks on High Pressure Natural Gas Transmission Mains—Their Causes, Prevention and Methods of Repair

By FRED E. WILSON
Pacific Gas and Electric Company

THE unparalleled expansion of natural gas systems and conservation laws instituted in the past five to 10 years has awakened utilities to the problem of eliminating gas leakage. Modern pipe line materials and construction methods have gone far to solve this problem.

In recent years the trend has been to place more confidence in the ability of the main transmission lines to furnish a constant, uninterrupted flow of gas to the terminals and consequently less reliance is placed on terminal storage facilities. This being true, greater economies in capital investment are possible.

The reason for this trend is, that modern construction has lessened the hazard of leaks; and improved methods of repair and speed in transportation have decreased the period of time a line is out of service for repairs.

Leaks caused by ruptured pipe or fittings are more liable to occur during the period between installation and end of the first wet season. As the soil settles firmly around the pipe and the line relieves itself of initial strains, this hazard decreases. Precaution used at the time of installing the pipe line, such as slack loops to induce compression strain instead of tensile, backfilling at times when the atmospheric temperature is more nearly the minimum ground temperature, expansion joints and anchorages at exposed joints, casing pipe under highways and proper construction at stream crossings, will remove many of the hazards from this period.

Modern construction, using the electric arc and oxy-acetylene methods of welding, has eliminated the use of flexible and threaded couplings. The use of the bell joint and manufactured bends has reduced the hazards of rupture at points of greatest strain.

The old method of cutting coupons from completed pipe welds for purpose of making a tensile test on a welder's work is becoming obsolete. Welders are now proven efficient before they are hired for the job. It was found that more leaks developed later in replaced coupons than in defective welds. Welding supply companies have perfected equipment and welding technique that have greatly reduced the personal factor or error. These companies have developed a keen rivalry over the relative merits of their products and this has resulted in a great saving in cost as well as increased efficiency for the pipe line companies.

Too much cannot be said on the importance of having trained and conscientious inspectors on a pipe line installation. They should have had experience in operation as well as construction and should be able to recognize problems that may cause trouble after several years of operation. This is especially true of wrapping inspectors.

Since the advent of long transmission lines, the problem of combating corrosion due to chemical and galvanic action of the soils has become a major problem. Intense research is being carried on by all major companies. To date the perfect wrapping to suit all conditions is still to be perfected. Cathodic protection, using corrosion eliminators, is a long step forward in corrosion mitigation. This method is still somewhat limited in scope on account of the location relative to power supply. Windmills and like apparatus are being tried at remote locations as a source of power.

Soil surveys made prior to the line's installation will determine the intensity of wrapping. It is said by some experts that the entire line should be insulated and the results of the soil survey used only in deciding the thickness of the wrapper. Recent research on this subject has surely substantiated this statement.

Leaks caused by defective fittings, gaskets and valve packing glands are few since the advent of cast steel fittings and improved packing materials. Fittings showing signs of leaking through the casting should be removed from service and replaced. Even a small porous leak may signify a defective casting and the danger of a ruptured fitting is always present. A casting leak should never be caulked.

Most ruptures occur at angles, because any contraction or expansion of the line tends to place an excessive stress at this point. Butt welded angles are not to be recommended. The use of manufactured bends with bell joints has solved this problem effectively. Corrugated expansion joints make ideal bends, but the turbulence caused by the irregular surface decreases the efficiency of the bend. Angles located near fittings should be sufficiently anchored to relieve the fittings of all unnatural strains.

Expansion joints can prove a hazard or a boon in a pipe line, depending upon their location. Intelligent thought should be given to their location in the line, the most important location being adjacent to a fitting. This not only relieves longitudinal stress, but allows the fitting to be easily removed. If a line is properly installed there is no reason for expansion joints to be located at regular intervals throughout its length. The ground friction restrains the longitudinal movement within the limits of the elasticity of the pipe metal. Modern welding practice gives a joint as strong as the parent metal. The elimination of these promiscuously located expansion joints, of the gasket type, decreases many sources of leakage and blow-outs. The use of expansion joints in compressor discharges is necessary, but at right angles or dead ends concrete blocks with a screw jack bumper (Fig. 1) should be installed to prevent a blow out (Fig. 2). Where the line is insufficiently backfilled the pipe should be strapped to a substantial anchor.

Lines crossing stream beds should be laid sufficiently deep or spanned overhead. Invariably when lines are laid at a shallow depth under an innocent looking dry creek bed, the bed is subsequently deepened and the pipe exposed. If the exposed span is long, the buoyancy of the pipe under water plus the impact of the flooded stream creates a grave danger (Fig. 3). Exposed spans of this type can be relaid at a safe depth by excavating a sufficient

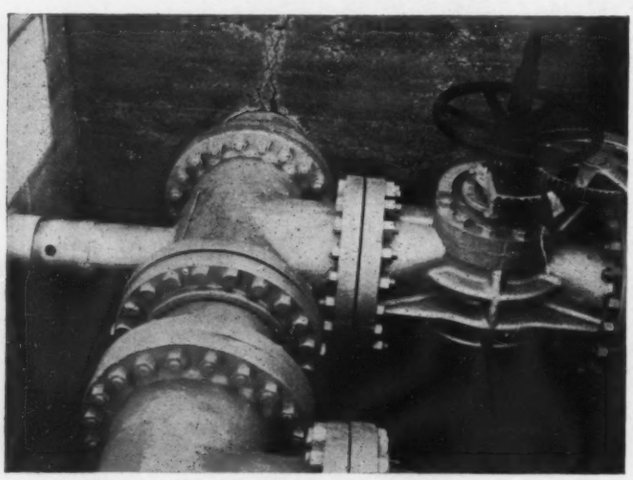


FIG. 1. Screw-jack bumper taking thrust.

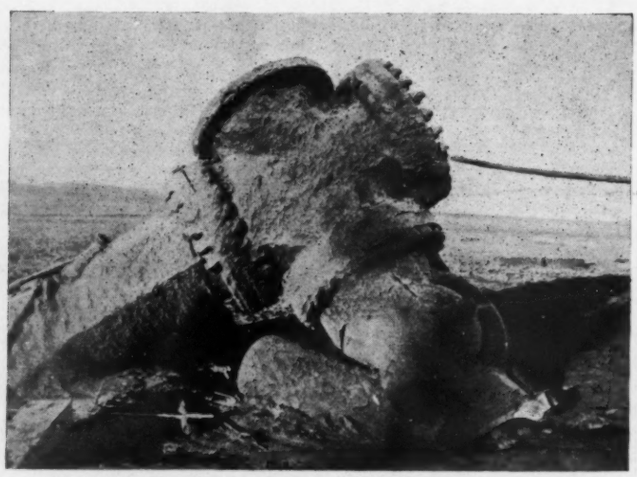


FIG. 2. Result of lack of provision against thrust.

FIG. 3. Nature uncovers a line and creates a hazard.

length on each side of the stream and allowing the pipe to sag in by its own weight. The pipe can then be heated at several places to relieve any strains set up in lowering. The line pressure should be reduced before the lowering operation begins.

Within certain limits, long unsupported spans do not create a serious hazard unless there is danger of the banks caving or washing out. If there is danger of the suspended portion of the span being lengthened it would be wise to butt strap the welds including the weld under backfill at each side of the creek. This work can be performed under pressure using the arc weld. The butt straps should be belled and reach entirely around the circumference of the pipe at the girth weld. If an "A" frame supports the pipe the saddle should not be clamped entirely around the line, but should be free to disengage if flood waters should wash it out from under the span.

Flood waters are a continual source of trouble to a pipe line. Trouble can be prevented, if the danger can be foreseen. As many of our transmission lines pass through arid country, cloudbursts create a dangerous condition, usually at points where the least trouble is expected. In gentle sloping country drainage systems and earthworks can be installed to divert the surface flow to regular channels. This prevents the water from flowing down the backfill and undermining the pipe line. Where the line is laid over hills and through dry washes it is sometimes necessary to excavate a new channel for the stream to prevent undercutting of hillsides. If this is not possible, a retaining wall is necessary to bolster the hillside and prevent undercutting. Sand bags are invaluable in reinforcing weak stream banks temporarily. They can be used as a permanent repair, if clean sand is used and a small proportion of cement is mixed with the sand. The aggregates set and give the performance of a rock wall. Pipe lines should always cross creek channels at a right angle and the channel should be straightened for a reasonable distance up stream from the crossing. Where the line is laid on steep hillsides, diagonal water runs should be installed at intervals down the slope to prevent the surface water from channeling down the backfill. Surface water entering gopher holes sometimes causes the line to sag and rupture. It is difficult to prevent this type of hazard. Fair results may be had by using squirrel poison to eradicate the squirrels from the close proximity of the line and filling the holes just before the wet season.

Much gas is wasted by the excessive blowing of drips. Drip valves should be choked so as not to blow gas while the liquid is being drained. Automatic drips can be installed at locations where heavy condensation is present. This not only prevents wastage of gas but the drips efficiently discharge the liquids preventing an excessive accumulation in the pipe.

An occasional leakage results from ruptured regulator diaphragms. This cannot always be prevented but by using a dual weight loaded regulator set-up, dash pots can be installed so that when a diaphragm ruptures, the gas pressure entering the top chamber of the diaphragm case will be transmitted to the dash pot, thereby actuating the piston which contacts the lever arm. The regulator is shut off by this action and the auxiliary regulator carries the load. (Fig. 4). Dual set-ups are recommended on all remote regulator stations. Regulator heaters on both primary and pilot regulators are necessary during the winter months. At stations where lighting circuits are available a small pilot regulator heater can be constructed, using a common carbon filament lamp as the heating element. At remote stations a calcium chloride filter pot ahead of the pilot regulator is effective in drying the gas before it enters the pilot regulator and preventing freezing. If the remote station is on the telephone line, a simple alarm system can be constructed. (Fig. 5). The function of the alarm is that an abnormal pressure condition causes the pressure gauge to contact, actuating a ringing machine which induces a code ring on the telephone. The code ring is received at the terminal switchboard and the repairman is immediately dispatched to the scene. Relays prevent interference with the telephone service in case of failure of the apparatus. The spacing of the ring is such that normal conversation may be carried on while the alarm is being sounded.

After the line has been in service for several years the most common of all leaks start to appear. These are leaks caused by corrosion of the pipe metal, electrolysis from galvanic currents and the chemical action of the soils. The only prevention is proper insulation of the pipe line in relation to the soil, and cathodic protection when the insulation breaks down. No doubt the day will come when a pipe metal will be found that will resist this source of trouble. With the present methods, the first cost of protection should not be considered as excessive to adequately protect a pipe line.

Through areas where it is suspected that corrosion is probable, test holes should be excavated and the pipe inspected. Test hole reports should be made out, describing the condition of the pipe. These reports should be kept on file and at regular intervals the section can be reopened to note the progress of corrosion. Electrolysis surveys, made after the winter rains cease, determine the locations of positive areas. These checks will show that many conditions exist that were not hitherto suspected. All excavations that expose the pipe should be considered as test holes and inspection reports made up reporting the condition of the pipe. Adequate drainage systems, preventing water from collecting in low areas,

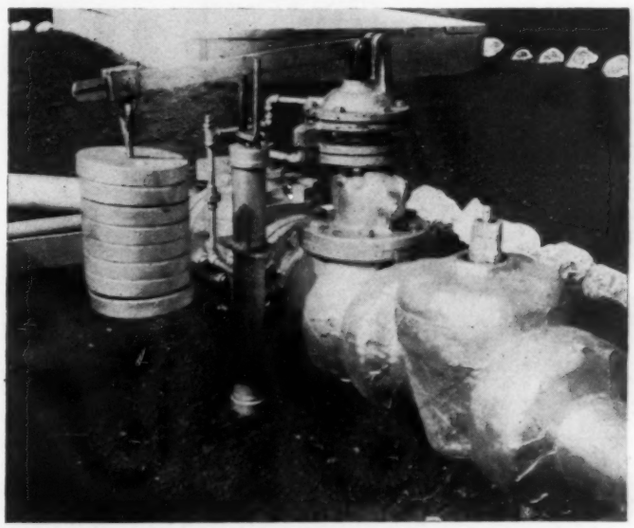


FIG. 4. When this regulator diaphragm ruptures an auxiliary regulator is brought into play by this dash-pot.

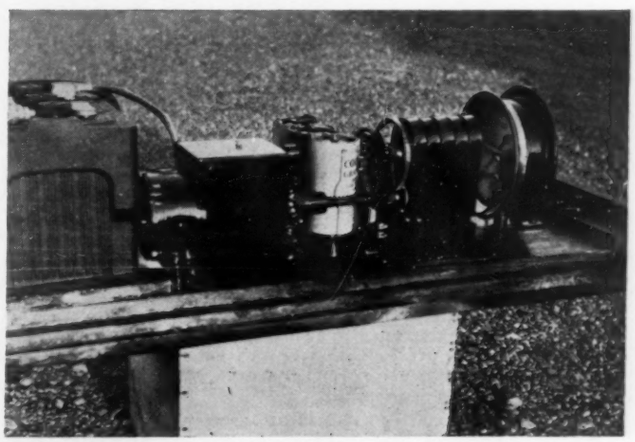


FIG. 5. Automatic alarm warns dispatcher of regulator failure.

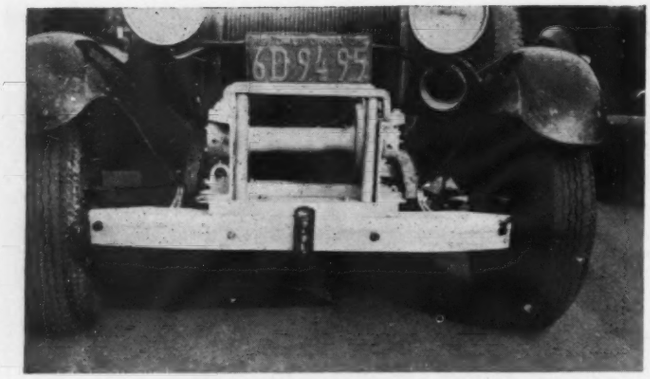


FIG. 6. A novel idea on a winch for a light truck.

prevent many locations from becoming positive. Long transmission lines, passing through myriads of dissimilar soil conditions, have created a vital problem for the pipe line companies.

Locating Leaks

Leaks are located by various indications on the surface of the ground. A large rupture is usually of sufficient size to cause the gas to blow out the backfill and the sound of escaping gas can usually be heard for various distances up to several miles. A wise company will pay a stipulated amount of money to a non-employee for reporting a leak. This is very effective and creates friendly public relations. It is surprising how alert ranchers become in detecting leaks. Many leaks that might not have been located for hours or days are reported only a few minutes after they have developed, saving the company an immense volume of lost gas. Leaks of sufficient size to indicate unusual line loss are located by immediate patrol, first patrolling areas where the line is most isolated and mountainous.

Small leaks can only be located by patrolling on foot over the entire length of line. Routine foot patrols should be made at least twice monthly. The patrolman should concentrate his attention on the ground surface directly over the pipe line. He should be on the lookout for dead or dying vegetation, gas odor, gas indications in the atmosphere directly over the leak, and the sound of escaping gas. In grain fields spots showing unhealthy condition should be marked for future inspection. Extreme care must be used in orchards. A tree showing signs of sickness and located near the right-of-way may indicate a gas leak nearby. Prompt action will save the tree. After the leak is repaired the soil around the roots of the tree should be thoroughly aired. In the winter season after heavy rains, leaks are indicated by gas seepage through standing surface water. These locations should be staked as soon as noted so that their location will not be lost. The use of gas indicators for locating gas leaks in open country is somewhat limited. They can be used for sampling air taken from holes that have been made by driving a bar down to the pipe line through its backfill.

Many leaks are reported by people residing near a station where the gas is odorized. These usually turn out to be the odors from the spilled liquid or from the discharge gas that is blown to the air when the odorizer is being recharged. If complaints are received from this source, equipment must be installed to dissipate the odor before it reaches the nearby residents.

Repairing Leaks

Methods of repairing leaks may be divided into two classes—one where the leak is of such magnitude that the line pressure must be blown down to atmospheric before attempting repairs, and the other, repairs made on a line under full pressure.

Proper equipment and trained personnel are necessary to the repairing of leaks on high pressure transmission lines. Inasmuch as the matter of prime importance is to maintain uninterrupted service, many devices have been introduced to repair leaks without a line shut down.

Maintenance stations are situated along the pipe line at the most strategic points. The station personnel usually consists of a foreman and three men, one of the men a welder. Some terminal stations have a larger personnel according to the scope of their work. The minimum crew of three or four can handle the majority of work except possibly a major trouble. Assistance can be furnished by the adjacent station, if needed.

The station emergency equipment usually consists of the following:

Oxy-Acetylene welding apparatus
Portable arc welding machine mounted on a pneumatic-tired trailer
Light express body trucks
Heavy 2- or 3-ton truck equipped with winch and boom
Caterpillar tractor, Hillside type with winch
Light pipe dolly
Tractor trailer
Hand and special tools
Materials of repair
Safety devices and equipment

The tractor is an invaluable piece of equipment on the pipe line. It can be used to gain access to almost inaccessible locations. During flood conditions the tractor can be depended upon to ford swollen streams where ordinary equipment cannot pass. As a power tool it performs the work of many men. Fast, mobile equipment is necessary to move men and equipment to the job in the shortest possible time. Another recent valuable addition is a winch mounted on the front bumper of the light express truck. (Fig. 6.) This is used mainly through marshy country to move stalled equipment from mud holes and also for light excavation and backfill.

On a repair requiring a line shut down, usually a severe rupture in the weld, the necessary clearance from the dispatcher is requested and equipment moved to the job. Men are sent to each valve to isolate the section and the gas in the isolated section is blown to the air through blow-offs located at each valve. The men at the valves are in telephone communication with the foreman, who is at the leak site with the welder. When the line pressures are 400 to 500 lbs. per sq. in. the blowing down period consumes 30 to 45 minutes, depending upon the length of section isolated. After the section is down, one man is left at the valve to regulate his blow-off vent and the other man closes the blow-off vent at his location and returns to the leak site to assist the welder. When the foreman ascertains that the amount of gas leakage at the rupture is sufficient to prevent air from entering the line, also not excessive for the weld, he permits the welder to proceed with his repair. The man stationed at the blow-off vent must observe his vent closely while the repairs are going on to prevent a suction inside of the pipe from drawing air into the line. This would create an explosive mixture and if this mixture reached the heat of the weld it would explode. He must close his valve at the least indication of a suction from within the pipe. The foreman, acting as observer on the job, must be in close communication with the man at the valve. The welder then cuts away the defective metal and welds in a fast filler weld. This stops the small gas leakage and he can make his finish heavy weld without the influence of the burning gas. When the weld is almost completed a man is dispatched back to the unattended main line valve and as soon as the weld has been relieved of welding strains by annealing, the section is packed from the upstream valve. If the repair is tight the down stream valve is opened and the line is back in service. An average time of two hours is required for the entire operation. After service is restored a butt strap, covering the entire repair, is welded on with the electic arc method. This makes it doubly certain that the rupture will not occur again at that point.

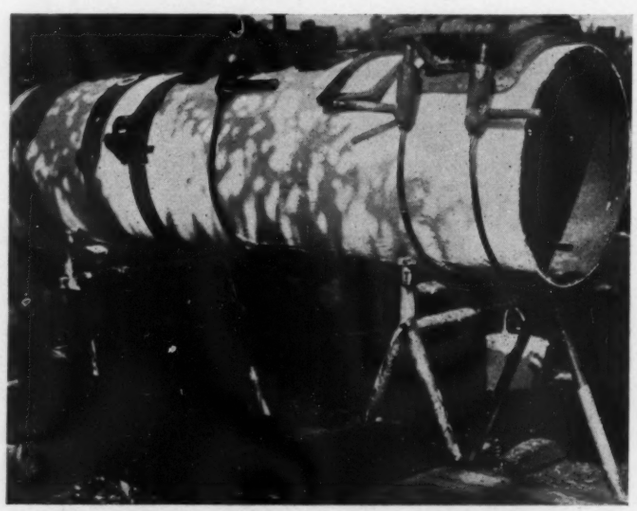


FIG. 7. Clamps for small pit holes and porous weld leaks.

This same procedure is used on all repairs where the line is shut down for welding. Speed with safety is vitally necessary and the dispatcher must be notified at intervals as to the progress of the work so that he may adjust his load accordingly. The men must be trained to coordinate their various duties. All orders given over the telephone should be repeated to prevent a misunderstanding. The job would be much more difficult if telephone service was not available. The telephone line is a boon to the pipe line man and a necessary adjunct to the pipe line.

Methods of repairing leaks on a transmission line under pressure are many. The so-called "hot repair" is desirable where the conditions will permit. This method is economical and in no way interferes with the load condition. The advent of the arc welder has made it possible to weld on a pipe under extreme high pressures without danger of penetrating through the pipe walls. A patch was devised by one of the employees whereby large size leaks could be repaired on a line under full pressure. This patch, made in various sizes to fit the circumference of the pipe and length of rupture, is clamped over the leak by a yoke and cables. The cables are taken up with screw connections until the patch is firm and gas tight on the pipe wall. The escaping gas is led off through a nipple vent and valve to a point remote from the leak site. The gasket is made of soft rubber. After the patch is in place it is tested with soap suds. Very little pressure builds up within the patch, as the vent relieves this condition. The patch is then tacked to the pipe wall, the yoke removed, leaving the vent in place, and the finish weld is installed. A speed electrode is used at low amperage. After the weld is complete the valve is closed and the lead-off piping removed. The valve is left on the patch and can be salvaged at some later time when the line is taken out of service.

Almost any type of leak can be repaired by this method. It has been used successfully on ruptures 14 inches long at 400 pounds gas pressure. It is especially adaptable to repairing corrosion leaks. The equipment can be made up at the station welding shop. The gaskets are made up in various sizes by a local vulcanizing shop. The saving in gas wastage is enormous, not to mention the value of the method in maintaining service while repairs are in progress.

Small corrosion leaks or pit holes can be repaired by the same method except that, instead of using a special vented patch, a steel plate with a rubber disc can be compressed over the pit hole, sealing the leak. (Fig. 7). The plate can then be welded in place. This is desirable when only a small pit hole is leaking but where the pitted area, not yet through the wall, covers a considerable area around the leak. The plate can be made to encompass the entire affected surface. Special patches can be constructed, on the job, to fit almost any condition.

Where an entire length of pipe is pitted, to a dangerous point, a casing made from a larger diameter pipe and split longitudinally can be arc welded in place without shutting down the line.

Porous weld leaks should never be caulked, as it is a simple matter to arc weld small vented patches without gaskets over the leaking area. Porous fittings should be replaced, as attempts to repair them under pressure are liable to prove extremely hazardous.

There are many leak clamps on the market for repairing leaks on lines under pressure. The straight band clamps (Fig. 7) are adaptable to small pit holes and porous weld leaks. They can either be left on as a permanent repair or later replaced with a welded patch. The gaskets are rubber discs which are compressed over the leak by tightening the side bolts of the clamp. A speed wrench must be used in taking up on the bolts to prevent the friction of leaking gas burning the gasket. They are valuable for installing at difficult locations or under water. They are light weight and very economical. They are manufactured in various styles for fitting over welds or on flat surface pipe.

For repairing large leaks with a clamp, various heavy cast steel split sleeves with gas vents are manufactured. They can be used on ruptured welds and have about the same capacity as the welded leak patch previously described. Unless a special fitting is used, they cannot be installed at angles. The center casting is in two sections that fit loosely around the circumference of the pipe and join with gasketed side flanges. The end flanges fit in sections and a split gasket is used to take up the leakage around the circumference. The center of the casting is hollowed out to encompass the weld and a vent at the top relieves the pressure from the clamp. After the clamp is tight the valve on the vent is closed. This method of repair is only temporary and the clamp should be removed at the time of a line shut down and the rupture welded. These clamps are heavy and cumbersome. Since the advent of the arc welder they are seldom used. Their greatest value lies in the fact that it does not take a skilled mechanic to install them. At times when a welder is not available or the weather conditions make it difficult to transport the arc welding machine they become useful.

Some gathering lines in the oil fields pass through tank farms and trap locations or near absorption plants where a welded repair is impossible on account of the gasoline vapors. The split sleeve is the only type of repair that could be used in these areas. Special angle type sleeves can be constructed (Fig. 8) or purchased for use on an angle. Bleeder drips can be installed on the pipe lines passing through these areas by closing down the line and bolting on a boiler flange using a lead gasket. A device has lately been placed on the market whereby stoppers can be inserted in a high pressure line on each side of a leak or section to be isolated and drained of gas. The gas flow can be by-passed around the section through the tapping apparatus. This method is invaluable on distribution systems, but its use is somewhat limited on a large transmission line.

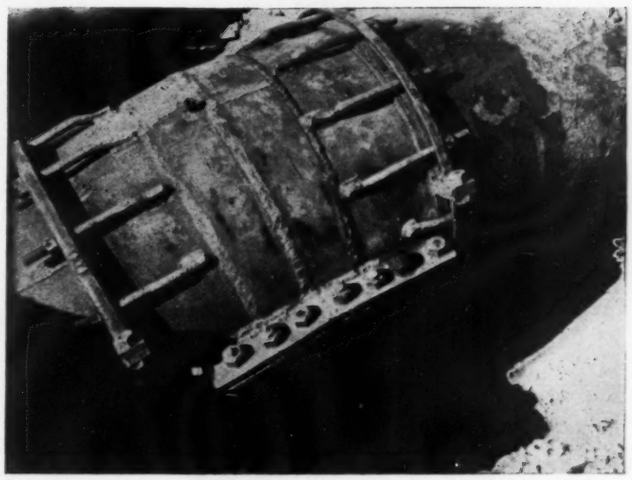


FIG. 8. Example of special angle sleeve.

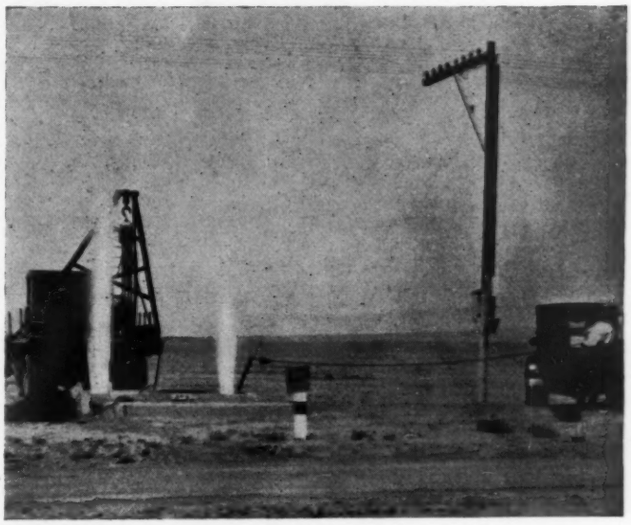


FIG. 9. For safety this valve wrench is operated by block and tackle.

Safety measures peculiar to each type of repair must be enforced and the necessary safety equipment must be available. Hazardous work should only proceed as the foreman directs. Before the men are allowed to work where escaping gas is present they should remove all matches, lighters and fire hazards from their person. They should use spark-proof tools in an escaping gas area. These tools can be purchased and are very satisfactory. They should be ground frequently to prevent the striking surface becoming glazed. Any type of tool can be duplicated in spark proof metal. Men excavating a leak location where the gas is blowing particles of dirt or sand should wear goggles. The welder and assistant should wear asbestos clothing. Friction surfaces of leak equipment should be bronze faced to prevent sparking. Gas masks should be available although they are seldom necessary in open country. The area around the leak should be cleaned of dry, inflammable vegetation. Fire extinguishers, 10-gallon cans of water, canvas strips and sacks soaked in water should be available on all jobs where a flame is used. Wrenches, used to open blow-off valves when blowing down the line, should be equipped with rope extensions so that a man operating the valve can stand at a safe distance in case of fire. (Fig. 9).

Bystanders should not be allowed within the dangerous area. All automotive equipment should be equipped with spark arresters on exhaust pipes and not be driven too close to the location. The pipe should be bonded where a fitting or section of pipe is to be removed. The open ends of pipe, when a valve or section has been removed, should be plugged until the space has been filled. This prevents air entering the pipe and creating an explosive mixture. After the replaced section is fitted in place the line should be purged with gas to eject any air that has entered the line. First aid kits and burn kits are carried on the job. The men are trained in artificial respiration and treatment of shock. Portable barriers should be constructed to place around temporary excavations. This prevents stock from falling into the hole.

Blow-off vents should never be located under or near high power electric lines. The vapors in the gas blowing into the wires can become a conductor, creating a short circuit and the resulting arc ignite the gas. The blow-off piping can be extended to a point remote from the power line.

Tests were made at an excavation similar to a leak excavation to determine the explosive hazards of gas leaking from various sized leaks at the bottom of the pipe. A gas indicator was used to register the degree of explosibility. It was found that a small leak similar to a pit hole and a medium leak similar to a large pit hole or a small rupture, not heavy enough to undermine the bottom of the excavation but leaking enough to blow loose particles of dirt from the hole, created an extremely dangerous mixture in the hole and for a distance of 10 to 15 feet from the rim of the hole on the lee side.

A large leak, heavy enough to deeply undermine the soil by the force of escaping gas, did not show dangerous mixtures in the hole, but at a distance of 15 to 30 feet away from the hole on the lee side the mixture was explosive. These tests were made in a breeze varying from 1 to 10 miles per hour. The point brought out here is not to define limits of dangerous areas but to show that the so-called small leak is more hazardous than the heavy blow. The men are apt to become careless when working around a small leak. Under these conditions an extensive area adjacent a leak of any size should be considered hazardous.

Lanterns and flash lights used should be of the approved underwriters type. Portable telephones should be installed outside the gaseous area. No more men should be working in the area than is necessary so that, in case of an accident, help would be available. The hole should be excavated in such a manner that a ramp is available for quick exit from the hole. Tools should never be thrown from the hole and fittings should be carefully lowered with ropes. New employees should be thoroughly instructed in the value of safety. When the proper safeguards are used the work is no more hazardous than any physical job. In seven years of operation of the pipe line referred to in this paper, not even a near serious accident has occurred to an employee.

Good pipe line roads are necessary for quick transportation to leaks and for locating trouble. The roads should be kept well graded and drained, bridges and culverts installed at gullies and washes, road signs located at laterals to direct to various locations. These signs are very useful at night. Spare pipe is located at intervals along the road for emergency repairs to the line.

Neatness of properties promotes efficiency and creates a good impression on the public. The duties of the personnel at the pipe line stations are varied and many. Each man is required to be a master of many trades. In the winter months they are called upon in times of almost impossible weather conditions and at any hour, day or night. They always get through to the scene of trouble regardless of conditions and location. With modern equipment and methods of repair, service interruptions are becoming a rarity.

Clearance Pockets for Transmission Line Compressors

By HARRY J. SMITH

Pacific Gas and Electric Company

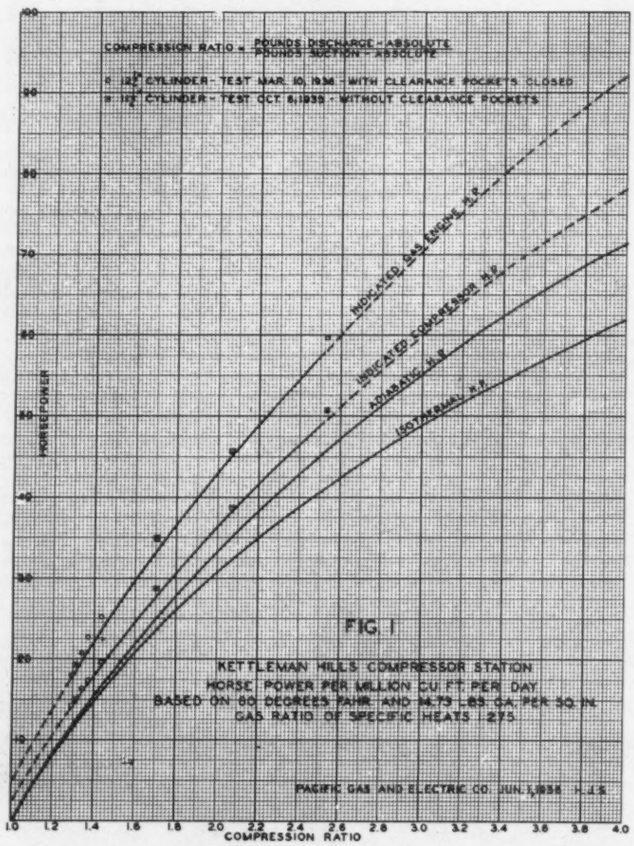
ON November 25, 1935, the seven compressors at Kettleman Hills Compressor Station were equipped with fourteen 12½-inch diameter compressor cylinders. Each cylinder has four clearance pockets in the outboard end and each pocket has a displacement of 575 cubic inches. These cylinders have two inlet and two outlet valves of equal area in each end of the cylinders and are designed for a maximum discharge pressure of 525 pounds gauge.

The original installation had 11½-inch diameter compressor cylinders with no clearance pockets. The cylinders had two inlet and two outlet valves of equal area in each end and were designed for a maximum discharge pressure of 450 pounds gauge.

The gas engines of each compressor unit are rated at 900 indicated horsepower and are of the twin tandem type with 19-inch diameter power cylinders with a 24-inch stroke and 180 revolutions per minute. The compressor cylinders are direct connected to the power units and are of the double acting type.

At the Kettleman Hills Compressor Station the suction pressure varies between 385 and 400 pounds gauge, and with a 500-pound gauge discharge pressure the compression ratio is from 1.29 to 1.24. With low compression ratios, as just mentioned, it was possible to increase the diameter of the compressor cylinders from 11½ inches to 12½ inches. At a suction pressure of 385 pounds gauge, there were available 270 horsepower for additional capacity and an increase in pressure. This is shown very clearly in Fig. 2.

In this installation of 12½-inch diameter cylinders it was necessary to install clearance pockets for the reason that should the suction pressure drop below 385 pounds gauge, with 500 pounds

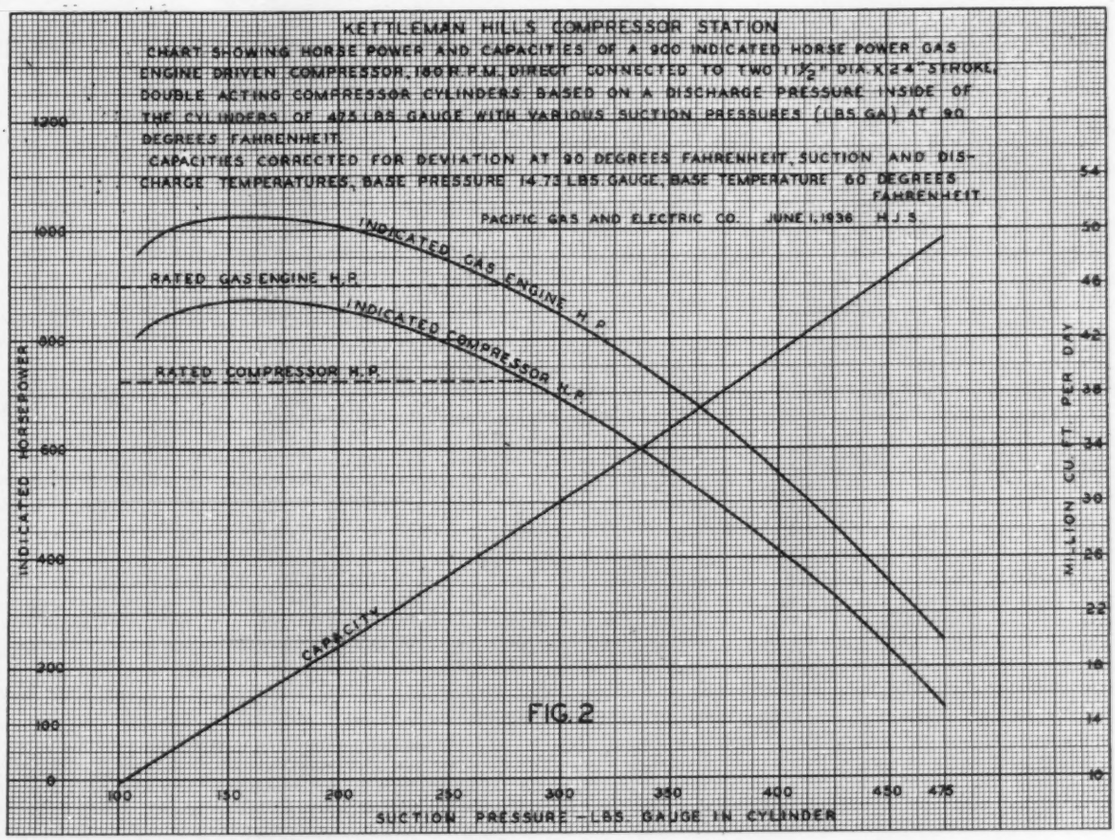

COMPRESSION RATIO = POUNDS DISCHARGE - ABSOLUTE / POUNDS SUCTION - ABSOLUTE
C 12½" CYLINDER - TEST MAR. 10, 1936 - WITH CLEARANCE POCKETS CLOSED
H 12½" CYLINDER - TEST OCT. 6, 1935 - WITHOUT CLEARANCE POCKETS
INDICATED GAS ENGINE H.P.
INDICATED COMPRESSOR H.P.
NOMINAL H.P.
ISOTHERMAL H.P.
HORSE POWER
COMPRESSION RATIO
1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0
FIG. 1
KETTLEMAN HILLS COMPRESSOR STATION
HORSE POWER PER MILLION CU. FT. PER DAY
BASED ON 60 DEGREES FAHR. AND 14.73 LBS. DA. PER SQ. IN.
GAS RATIO OF SPECIFIC HEATS 1.275
PACIFIC GAS AND ELECTRIC CO. JUN. 1, 1936 H. J. S.

gauge discharge the gas engine would be overloaded; therefore it is necessary to open and close clearance pockets to keep within the horsepower rating of the gas engines, as shown in Fig. 3.

If the unit is to operate over a wide range of suction pressures, the cylinders should have eight clearance pockets, four in each end. This arrangement would give finer volume control on low suction pressures as it is necessary to open or close only one pocket at a time, thereby requiring smaller clearance pockets. With a high suction pressure two pockets can be opened or closed at a time in order to hold within the rated horsepower of the unit. Therefore larger pockets are recommended for this condition.

On the 12½-inch diameter cylinders there are internal and external pockets and should a finer volume control be desired, a valve can be placed between the internal and external pockets. The opening of pockets does not unbalance the unit; so therefore any of the pockets can be opened.

Another reason for the installation of clearance pockets is that when the units are operating at full capacity, and a small fraction of the capacity of another unit is required to take care of the load,


KETTLEMAN HILLS COMPRESSOR STATION
CHART SHOWING HORSE POWER AND CAPACITIES OF A 900 INDICATED HORSE POWER GAS ENGINE DRIVEN COMPRESSOR, 180 R.P.M. DIRECT CONNECTED TO TWO 11½" DIA. X 24" STROKE, DOUBLE ACTING COMPRESSOR CYLINDERS BASED ON A DISCHARGE PRESSURE INSIDE OF THE CYLINDERS OF 425 LBS. GAUGE WITH VARIOUS SUCTION PRESSURES (LBS. GA.) AT 90 DEGREES FAHRENHEIT.
CAPACITIES CORRECTED FOR DEVIATION AT 90 DEGREES FAHRENHEIT, SUCTION AND DISCHARGE TEMPERATURES, BASE PRESSURE 14.73 LBS. GAUGE, BASE TEMPERATURE 60 DEGREES FAHRENHEIT.
PACIFIC GAS AND ELECTRIC CO. JUNE 1, 1936 H.J.S.
INDICATED GAS ENGINE H.P.
RATED GAS ENGINE H.P.
INDICATED COMPRESSOR H.P.
RATED COMPRESSOR H.P.
CAPACITY
INDICATED HORSEPOWER
MILLION CU. FT. PER DAY
SUCTION PRESSURE - LBS. GAUGE IN CYLINDER
FIG. 2

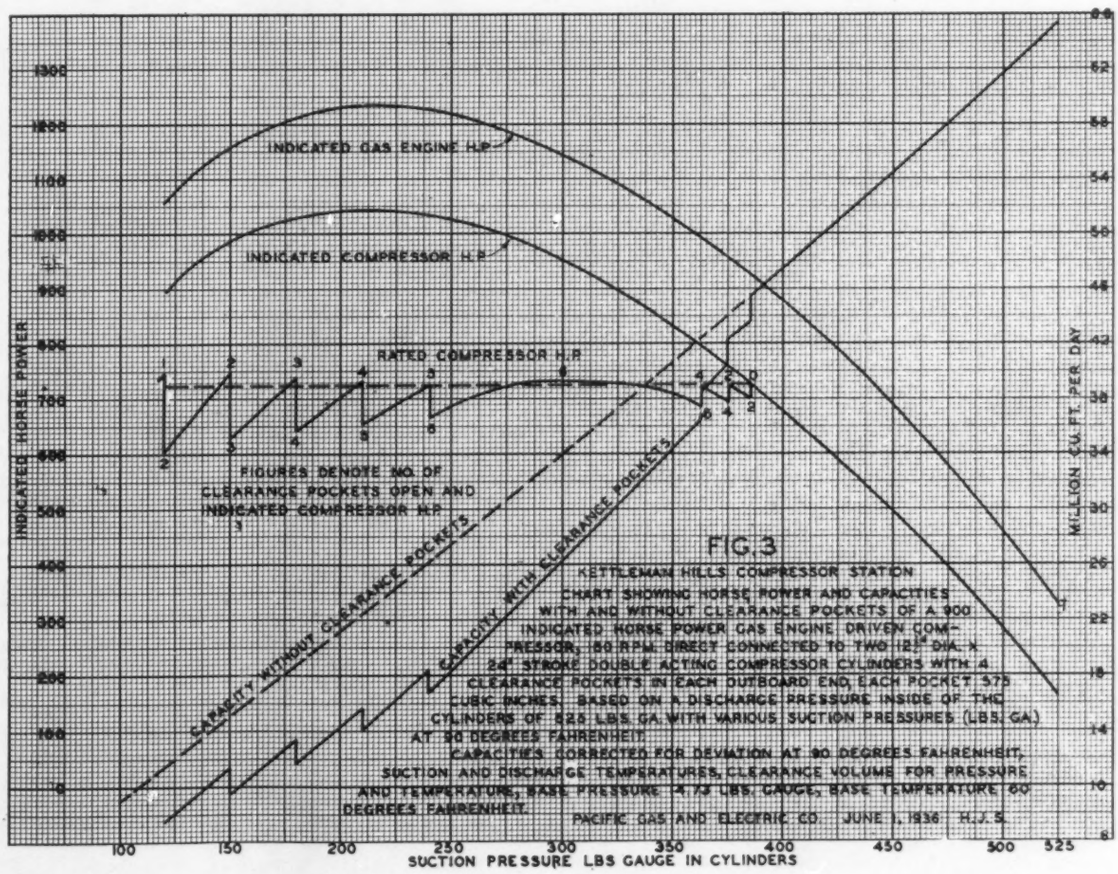

INDICATED GAS ENGINE H.P.
INDICATED COMPRESSOR H.P.
RATED COMPRESSOR H.P.
FIGURES DENOTE NO. OF CLEARANCE POCKETS OPEN AND INDICATED COMPRESSOR H.P.
CAPACITY WITHOUT CLEARANCE POCKETS
CAPACITY WITH CLEARANCE POCKETS
INDICATED HORSE POWER
MILLION CU. FT. PER DAY
SUCTION PRESSURE LBS GAUGE IN CYLINDERS
FIG. 3
KETTLEMAN HILLS COMPRESSOR STATION
CHART SHOWING HORSE POWER AND CAPACITIES WITH AND WITHOUT CLEARANCE POCKETS OF A 900 INDICATED HORSE POWER GAS ENGINE DRIVEN COMPRESSOR, 80 R.P.M. DIRECT CONNECTED TO TWO 18½" DIA. X 24" STROKE DOUBLE ACTING COMPRESSOR CYLINDERS WITH 4 CLEARANCE POCKETS IN EACH OUTBOARD END, EACH POCKET 575 CUBIC INCHES, BASED ON A DISCHARGE PRESSURE INSIDE OF THE CYLINDERS OF 525 LBS. GA. WITH VARIOUS SUCTION PRESSURES (LBS. GA.) AT 90 DEGREES FAHRENHEIT
CAPACITIES CORRECTED FOR DEVIATION AT 90 DEGREES FAHRENHEIT, SUCTION AND DISCHARGE TEMPERATURES, CLEARANCE VOLUME FOR PRESSURE AND TEMPERATURE, BASE PRESSURE 14.73 LBS. GAUGE, BASE TEMPERATURE 60 DEGREES FAHRENHEIT.
PACIFIC GAS AND ELECTRIC CO. JUNE 1, 1936 H.J.S.

TABLE NO. 1. KETTLEMAN HILLS COMPRESSOR STATION.
Test on No. 4 Twin Tandem Gas Engines, Cylinder 19-inch Diameter by 24-Inch Stroke. Duplex Compressor Cylinder 12½-Inch Diameter by 24-Inch Stroke with Clearance Pockets. (From Test on March 10, 1936.)

		PRESSURES (POUNDS GAUGE)			
Test Number	Card No.	Discharge, Compressor Cyl. at Valve Cap	Maximum on Card	Suction, Comp. Cyl. at Valve Cap	Minimum on Card Before Comp. Stroke
1 A	RHIB	501	563	385	384
1 A	RHOB	501	576	385	384
1 A	LHIB	501	560	385	384
1 A	LHOB	501	569	385	374
2 A	RHIB	505	-----	373	-----
2 A	RHOB	505	576	373	362
2 A	LHIB	505	566	373	371
2 A	LHOB	505	576	373	355
3 A	RHIB	504	573	363	362
3 A	RHOB	504	579	363	352
3 A	LHIB	504	566	363	358
3 A	LHOB	504	576	363	346
4 A	RHIB	503	557	348	330
4 A	RHOB	503	570	348	336
4 A	LHIB	503	560	348	343
4 A	LHOB	503	563	348	330
5 A	RHIB	503	566	348	329
5 A	RHOB	503	570	348	336
5 A	LHIB	503	566	348	346
5 A	LHOB	503	563	348	342
6 A	RHIB	504	570	336	330
6 A	RHOB	504	557	336	323
6 A	LHIB	504	570	336	334
6 A	LHOB	504	570	336	320
7 A	RHIB	504	576	337	330
7 A	RHOB	504	563	337	323
7 A	LHIB	504	579	337	336
7 A	LHOB	504	576	337	323
8 A	RHIB	504	570	327	320
8 A	RHOB	504	550	327	314
8 A	LHIB	504	570	327	323
8 A	LHOB	504	563	327	307
9 A	RHIB	504	576	325	323
9 A	RHOB	504	570	325	320
9 A	LHIB	504	576	325	320
9 A	LHOB	504	544	325	314
10 A	RHIB	504	566	294	288
10 A	RHOB	504	544	294	285
10 A	LHIB	504	554	294	288
10 A	LHOB	504	534	294	285
11 A	RHIB	505	554	268	266
11 A	RHOB	505	528	268	259
11 A	LHIB	505	566	268	266
11 A	LHOB	505	538	268	259
12 A	RHIB	502	544	218	195
12 A	RHOB	502	512	218	208
12 A	LHIB	502	566	218	204
12 A	LHOB	502	525	218	211
13 A	RHIB	504	538	217	214
13 A	RHOB	504	515	217	211
13 A	LHIB	504	563	217	214
13 A	LHOB	504	528	217	208
14 A	RHIB	503	557	199	195
14 A	RHOB	503	528	199	192
14 A	LHIB	503	560	199	195
14 A	LHOB	503	512	199	192
15 A	RHIB	503	550	197	192
15 A	RHOB	503	499	197	195
15 A	LHIB	503	560	197	195
15 A	LHOB	503	525	197	195
16 A	RHIB	503	560	164	163
16 A	RHOB	503	406	164	160
16 A	LHIB	503	566	164	163
16 A	LHOB	503	518	164	160
17 A	RHIB	501	557	166	163
17 A	RHOB	501	512	166	160
17 A	LHIB	501	554	166	163
17 A	LHOB	501	509	166	163

clearance pockets can be opened so that the units can be operated at the proper speed for good operation. There is a limit as to how low a speed the gas engines can operate and still give smooth performance without vibration. With the 12½-inch diameter cylinders, the lowest speed is 160 revolutions per minute.

The valve area is a very important factor to consider where large volumes of gas are to be handled. In the 11½-inch diameter cylinder each suction valve had an area of 7 square inches, and the velocity through the valve at the center of the stroke was 4200 feet per minute. In the 12½-inch diameter cylinder each suction valve has an area of 13 square inches, and the velocity through the valve at the center of the stroke is 2700 feet per minute.

The suction valve is the controlling valve, for should the area be too small, a greater pressure drop will occur, thereby reducing the capacity of the unit. If it is possible, the suction pressure on the inside of the cylinder should be the same as at the inlet to the cylinder, thereby increasing the capacity of the unit. If this is accomplished, the discharge valve, being of the same area, will take care of the volume without an excessive pressure inside of the cylinder at the center of the stroke.

Even with a suction valve velocity of 2700 feet per minute at the center of the stroke and with clearance pockets, the velocity through the suction valve would be about 2000 feet per minute, providing the compressor manufacturers can design suction and discharge valves of larger areas for transmission compressor stations.

In the original units with 11½-inch diameter cylinders and at a suction pressure of 385 pounds gauge inlet to the cylinder each unit was capable of delivering 35,000,000 cubic feet of gas per day, and with six units operating, the plant had a capacity of 210,000,000 cubic feet of gas per day at a discharge pressure of 450 pounds gauge. Fig. 2 shows that each unit should have a capacity of 39,000,000 cubic feet of gas per day but due to small suction valves, this was impossible.

The 12½-inch diameter cylinders operating at a suction pressure of 385 pounds gauge at the inlet to the cylinders are capable of delivering 45,500,000 cubic feet of gas per day, and with five units operating, the plant has a capacity of 227,500,000 cubic feet of gas per day at a discharge pressure of 500 pounds gauge. Fig. 3 shows the capacity, and from Table No. 1 the pressure drop through the valve is about 1 pound at 385 pounds gauge suction pressure. By increasing the capacity, the plant has two spare units, whereas previously the plant had but one spare unit.

Without the use of clearance pockets and with 500 pounds gauge discharge pressure the diameter of the cylinder would be about 10¼ inches in diameter, and it would be necessary to install two additional units of the same rated gas engine horsepower now installed to take care of the present capacity of the transmission line with 500 pounds gauge at the delivery end.

Fig. 1 gives the horsepower required per million cubic feet of gas per day for various compression ratios for the compressor and gas engines. On this curve are plotted tests that were made on the 11½-inch and 12½-inch diameter compressor cylinders. This curve is the basis for all the calculations.

With the use of clearance pockets, the higher compression ratios are of no great concern, providing that sufficient clearance pocket displacement is installed to keep within the rated compressor horsepower.

The capacity and horsepower of the original 11½-inch diameter compressor cylinders are shown in Fig. 2. This curve shows that the compressor cylinders had reached their rated horsepower at 285 pounds gauge suction pressure and unless clearance pockets were installed it would be impossible to go below this suction pressure. But, as stated previously, the main thought in writing this paper is to show how to take advantage of the 270 horsepower that are available at 385 pounds gauge suction pressure by installing larger diameter cylinders.

The capacity and horsepower of the 12½-inch diameter cylinders are shown in Fig. 3. This curve is calculated on the basis of 525 pounds gauge discharge pressure inside of the cylinder for 500 pounds gauge at the outlet of the cylinder.

According to this curve the compressor horsepower at a suction pressure of 210 pounds gauge would be 1040 horsepower and the compressor cylinders having a rating of only 725 horsepower, clearance pockets are the only solution to keep within the rated horsepower.

The 12½-inch diameter cylinders are designed for a maximum pressure of 525 pounds gauge and Fig. 4 shows that with a suction pressure of 385 pounds gauge, it would be necessary to open six pockets to operate at these pressures. If the suction pressure should drop and the discharge pressure be maintained, it would be necessary that only seven pockets be opened to keep within the rated horsepower of the compressor cylinders, and as stated before, each unit has eight pockets, showing that we have ample clearance pocket displacement. If the station could be operated on 525 pounds gauge discharge pressure at the outlet of the cylinders, the capacity of the transmission line could be increased about 7,000,000 cubic feet of gas per day. Should the suction pressure be increased to 415 pounds gauge the capacity of each unit would be 49,000,000 cubic feet of gas per day.

On March 10, 1936, a test was run on the No. 4 unit and this is shown in Fig. 5. This test was run to prove that there was suffi-

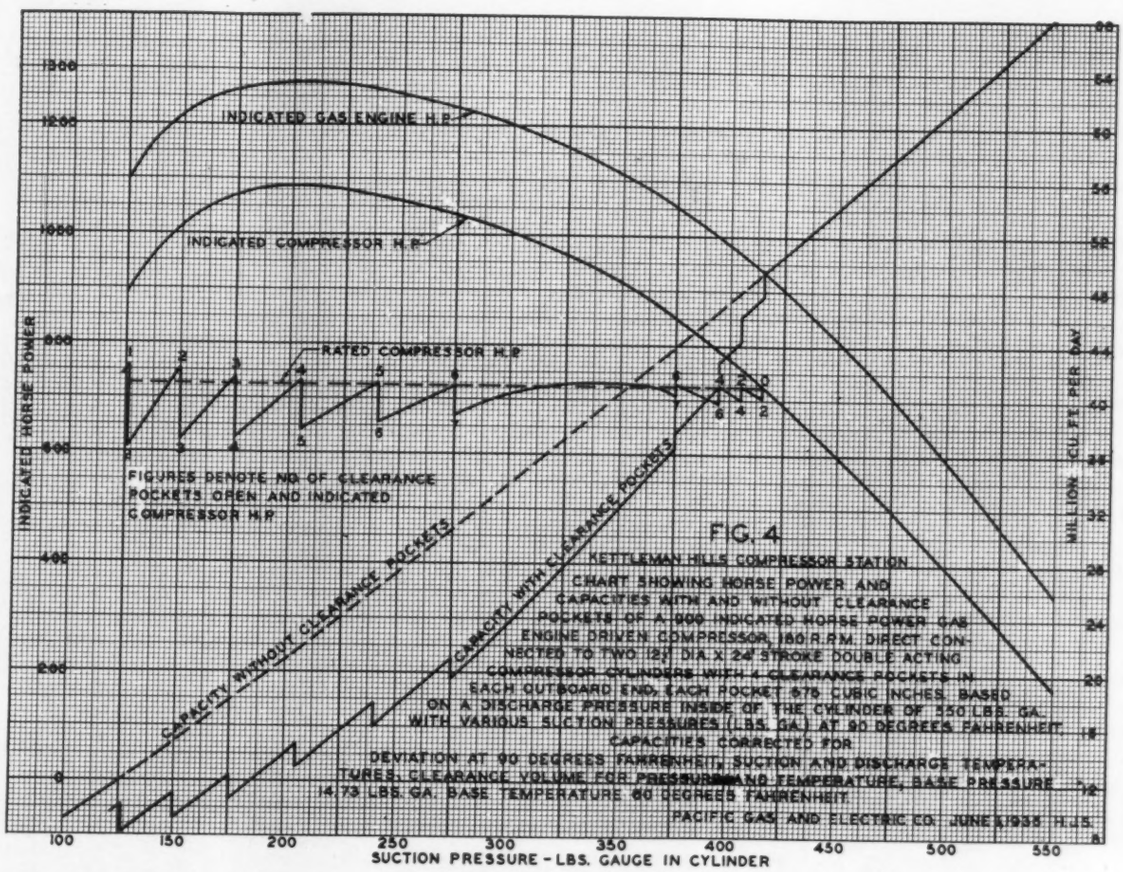

INDICATED GAS ENGINE H.P.
INDICATED COMPRESSOR H.P.
RATED COMPRESSOR H.P.
FIGURES DENOTE NO. OF CLEARANCE POCKETS OPEN AND INDICATED COMPRESSOR H.P.
CAPACITY WITHOUT CLEARANCE POCKETS
CAPACITY WITH CLEARANCE POCKETS
INDICATED HORSE POWER
MILLION CU. FT. PER DAY
SUCTION PRESSURE - LBS. GAUGE IN CYLINDER

FIG. 4

KETTLEMAN HILLS COMPRESSOR STATION

CHART SHOWING HORSE POWER AND CAPACITIES WITH AND WITHOUT CLEARANCE POCKETS OF A 900 INDICATED HORSE POWER GAS ENGINE DRIVEN COMPRESSOR, 180 R.P.M. DIRECT CONNECTED TO TWO 12½" DIA. X 24" STROKE DOUBLE ACTING COMPRESSOR CYLINDERS WITH 4 CLEARANCE POCKETS IN EACH OUTBOARD END, EACH POCKET 675 CUBIC INCHES, BASED ON A DISCHARGE PRESSURE INSIDE OF THE CYLINDER OF 550 LBS. GA. WITH VARIOUS SUCTION PRESSURES (LBS. GA.) AT 90 DEGREES FAHRENHEIT.

CAPACITIES CORRECTED FOR DEVIATION AT 90 DEGREES FAHRENHEIT, SUCTION AND DISCHARGE TEMPERATURES, CLEARANCE VOLUME FOR PRESSURE AND TEMPERATURE, BASE PRESSURE 14.73 LBS. GA. BASE TEMPERATURE 60 DEGREES FAHRENHEIT.

PACIFIC GAS AND ELECTRIC CO. JUNE 1, 1936 H.J.S.

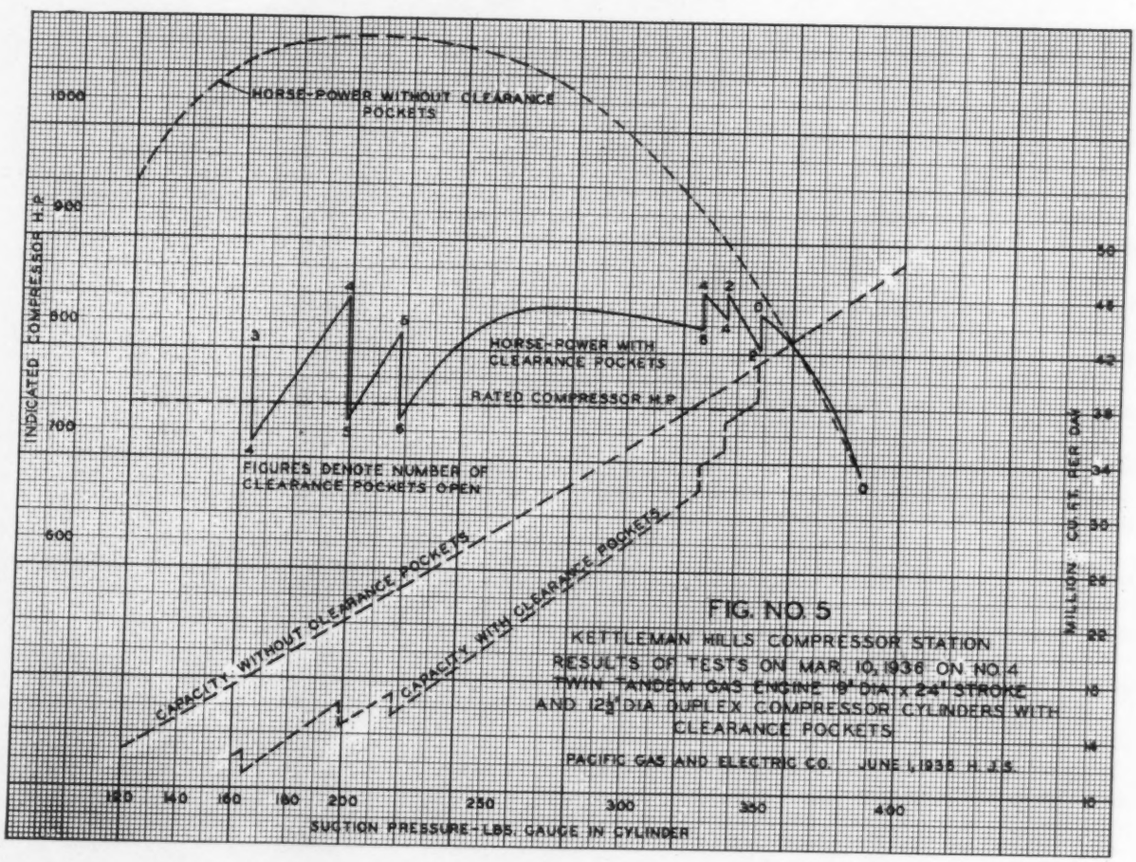

HORSE-POWER WITHOUT CLEARANCE POCKETS
HORSE-POWER WITH CLEARANCE POCKETS
RATED COMPRESSOR H.P.
FIGURES DENOTE NUMBER OF CLEARANCE POCKETS OPEN
CAPACITY WITHOUT CLEARANCE POCKETS
CAPACITY WITH CLEARANCE POCKETS
INDICATED COMPRESSOR H.P.
MILLION CU. FT. PER DAY
SUCTION PRESSURE - LBS. GAUGE IN CYLINDER

FIG. NO. 5

KETTLEMAN HILLS COMPRESSOR STATION

RESULTS OF TESTS ON MAR. 10, 1936 ON NO. 4 TWIN TANDEM GAS ENGINE 19" DIA. x 24" STROKE AND 12½" DIA. DUPLEX COMPRESSOR CYLINDERS WITH CLEARANCE POCKETS.

PACIFIC GAS AND ELECTRIC CO. JUNE 1, 1936 H. J. S.

TABLE NO. 2. KETTLEMAN HILLS COMPRESSOR STATION TEST ON THE NO. 4 TWIN TANDEM GAS ENGINES.

19-Inch Diameter by 24-Inch Stroke Duplex Compressor Cylinders 12½-Inch Diameter with Clearance Pockets.

(All Gauges Tested Before Running Test—Pressure Pounds Gauge).

Test	Time of Test		Temperatures		Suction Pressures		Discharge Pressures		RPM	Number of Pockets Opened (Cubic Inches)		Indicated Gas Engine Horsepower	Indicated Compressor Horsepower	Friction Horse-power	Mechanical Efficiency Per Cent	Compression Ratio at Valve Caps
	Start	Finish	Suction Header	Discharge at Cylinder Outlet	Cylinder Inlet	Inlet Valve Cap	Outlet Valve Cap	Cylinder Outlet		Left Hand Cylinder	Right Hand Cylinder					
	A.M.	A.M.														
1A	10:20	11:25	84.0	118	386	385	501	498	180	0	0	836.8	664.0	172.8	79.4	1.29
2A	11:20	12:N.	79.0	122	372	373	505	502	180	0	0	930.5	740.8	189.7	79.5	1.34
	P.M.	P.M.														
3A	1:25	2:05	80.2	126	361	363	504	501	180	0	0	991.6	761.9	229.7	76.9	1.37
4A	2:15	2:45	79.6	130	346	348	503	500	180	0	0	1036.2	813.0	223.2	78.4	1.43
5A	3:01	3:25	80.0	131	345	348	503	500	180	577	573	1012.9	775.1	237.8	76.5	1.43
6A	3:35	4:00	79.8	135	333	336	504	501	180	577	573	1035.0	831.3	203.7	80.3	1.48
7A	4:10	4:35	80.2	135	334	337	504	501	180	570 577	570 573	1013.0	806.5	206.5	79.5	1.47
8A	6:20	6:42	79.4	138	324	327	504	501	180	570 577	570 573	1056.7	829.7	227.0	78.5	1.52
9A	6:50	7:12	79.0	138	324	325	504	501	180	577 570 577	582 570 573	1022.9	795.4	227.5	77.8	1.53
10A	7:30	7:55	77.4	148	292	294	504	502	180	577 570 577	582 570 573	1004.9	806.6	198.3	80.6	1.68
11A	8:25	8:45	75.0	160	266	268	505	501	180	577 570 577	582 570 573	1000.2	815.8	184.4	81.6	1.84
12A	8:57	9:20	71.6	178	215	218	502	500	180	— 570 577	582 570 573	969.2	794.3	174.9	82.0	2.22
13A	9:30	9:50	70.4	180	213	217	504	501	180	577 570 577	582 570 573	888.0	708.0	180.0	79.7	2.24
14A	10:10	10:30	69.0	190	194	199	503	500	180	570 577	570 573	1016.7	823.7	193.0	81.0	2.42
15A	10:45	11:05	68.4	190	193	197	503	500	180	— 570 577	582 570 573	938.3	708.0	230.3	75.5	2.44
16A	11:20	11:40	66.8	209	162	164	503	500	180	— 570	570 573	971.2	773.0	198.2	79.6	2.89
17A	11:45	12:M.	66.0	209	165	166	501	500	180	570 577	570 573	868.7	689.0	179.7	78.4	2.85

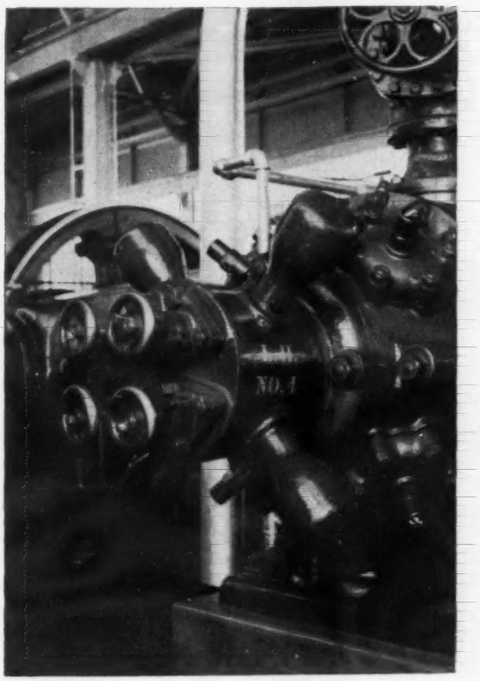


FIG. 6. Clearance pockets for compressor units at Kettleman Hills compressor station.

cient displacement in the clearance pockets. This test also determines the maximum compressor horsepower and if the compressors were to run continuously at this maximum horsepower, the maintenance on these units would be greatly increased.

Fig. 6 is a picture of the clearance pockets for the compressor units. Each internal pocket has 380 cubic inches and each external pocket has 195 cubic inches or a total of 575 cubic inches of displacement for both pockets.

Table No. 1 gives the maximum and minimum pressures on the inside of the cylinders, as indicated on the cards that were taken on March 10, 1936. The maximum pressure is about at the center of the stroke and is the maximum discharge pressure. The minimum pressure is at the end of the suction stroke and this gives an indication of the drop through the suction valves. This tabulation proves that large valve areas are absolutely necessary.

Table No. 2 summarizes the test of March 10, 1936. This tabulation shows that the suction pressure at the valve cap is greater than at the cylinder inlet. The gauges were tested before the test was started, but it was necessary to throttle the gauges so as to get the pressure readings. However, the reverse happens at the discharge valve cap. These pressure readings prove that there is a very small pressure drop between the inlet and outlet of the cylinders and the valve caps. The curve shown in Fig. 5 was plotted from this tabulation.

In conclusion, there is no doubt that clearance pockets have a distinct advantage for transmission line compressor stations and all compressor stations should be equipped with clearance pockets so as to meet any operating condition that may arise due to varying suction and discharge pressures.

Gas Dehydration by Calcium Chloride Brine Method

By W. K. Dodd

Southern California Gas Company

CALCIUM chloride has long been employed as a drying agent in the chemical laboratory but its use on a large scale for the drying of natural gas is of quite recent origin. The absorption of water from the surrounding atmosphere by calcium chloride crystals is a familiar sight. However, its ability to absorb water does not end when the crystal is entirely covered with liquid. Investigation has revealed that up to certain limits the solution of calcium chloride in water is able to extract the moisture from any gas mixture passed through it. This information led to the use of calcium chloride brine for gas drying purposes.

The Southern California Gas Co. had a particular gas drying problem to solve in the Ventura Field. One of its high pressure transmission lines extends from its Compressor Station No. 50 in Ventura through Hall Canyon to Mills Road Station, thence easterly to connect with the main transmission system at Castaic. Low ground temperatures in Hall Canyon, a mountainous section, resulted in the deposition of liquids in the pipe line in all except five warmer months of the year. Test coupons placed in the gas flow revealed some corrosive action within the pipe line. For that reason it was deemed necessary to provide some means for the removal of the liquids or moisture from the gas before entering the line. The depression of the dew point of gas below the ground temperatures in Hall Canyon was the logical and desired goal. This could be accomplished by means of the calcium chloride drying process. This method was chosen because of its low installation costs, its low operating costs in connection with equipment already available, and its positive moisture extraction within certain predetermined limits.

Accordingly a calcium chloride brine dehydration plant was installed at the Ventura Compressor Plant No. 50 of this company. It was designed and installed by Parkhill-Wade, Inc., of Los Angeles, Calif. Opportunity is taken at this time for acknowledgement to Mr. Wade of that company for much of the technical data appearing later in this article.

The calcium chloride brine plant was placed in operation in the discharge line of the above mentioned compressor plant on the 7th of November, 1935, and 11 days later the 16-inch transmission line through Hall Canyon was reported dry, all liquids standing in the line at low points having been picked up by the low dew point gas passing through it. The compressor plant in question has a winter load daily output of between 30 and 35 million cubic feet of natural gas at pressures varying from 300 to 400 lbs. gauge. The pipe line has remained dry since the date it was first reported so, excepting for shutdowns of the brine circulating system for repair or operating purposes.

A description of the equipment used in the Ventura installation follows:

(1) One 20-foot by 5-foot vertical cylindrical contact tower with four bubble plates, the tower being similar in design to the conventional absorption tower.

(2) One 6-inch by 8-foot gas trap or vent in which the calcium chloride brine returning from the contact tower is released to atmospheric pressure to allow the escape of gas absorbed in the brine while in contact with the gas under high pressure.

(3) One 8-inch by 68-inch gravitometer which is adjusted by means of weights in the float to control the concentration of the brine.

(4) One 5-foot by 5-foot open top cylindrical surge tank which serves as a reservoir for surplus brine in the system.

(5) One 12-inch by 24-inch by 42-inch concentrator or evaporator which has inclosed one ordinary cast iron wall radiator section, steam heated, over which the brine passes for the evaporation of excess water.

(6) One 6⅛-inch by 1⅝-inch by 10-inch steam-hydraulic pump, double acting, operated by gas pressure instead of steam. This pumps brine from surge tank into contact tower. Fig. 1 shows an operating diagram of the system. The operating cycle and details of operation follow:

Beginning with the contact tower, where the calcium chloride brine has been in contact with the high pressure gas to be dehydrated, the brine collects at the base of the tower, being maintained at a definite depth by a liquid level controller. The brine from here flows to a back pressure regulator (set at 5 pounds gauge) which is located just ahead of the gas trap. Just ahead of this regulator the brine flow divides into two streams, as follows:

(1) Through the regulator to the gas trap where it is released to atmospheric pressure and from which it flows by gravity to the gravitometer and on into the surge tank. This is the main flow and is continuous.

(2) Through the side stream to a regulator just ahead of the concentrator, thence by gravity over the steam heated radiator section in the concentrator to the surge tank. This regulator, which is controlled by air pressure from a valve operated by the float in the gavitometer, opens as the main flow gravity decreases

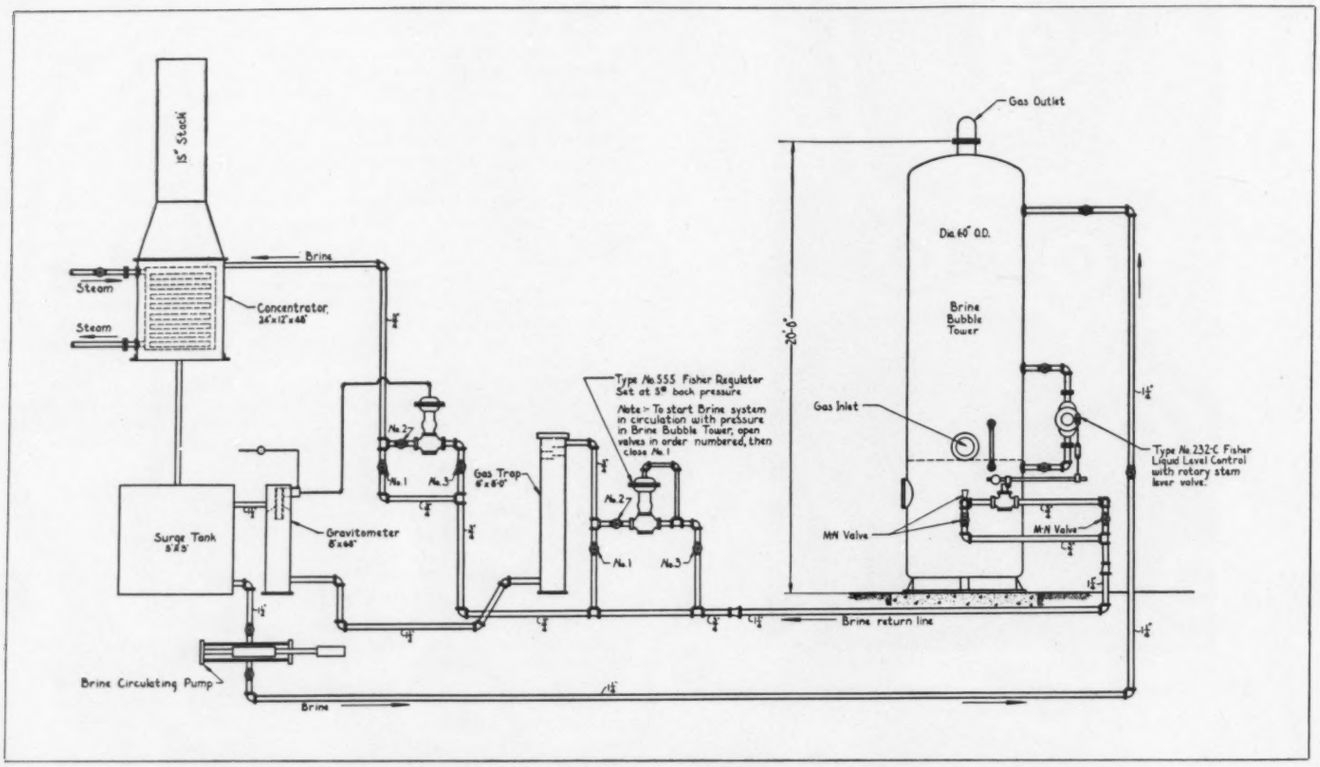


FIG. 1. Operating diagram of Southern California Gas Co.'s calcium chloride brine dehydration plant at Compressor Station No. 50, Ventura, California.

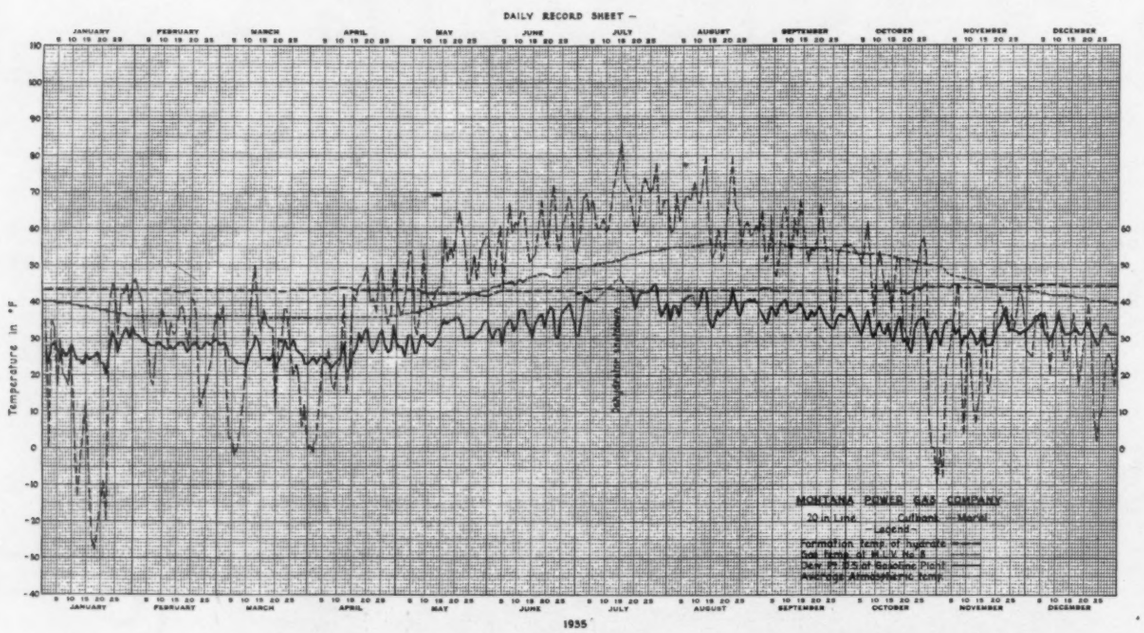
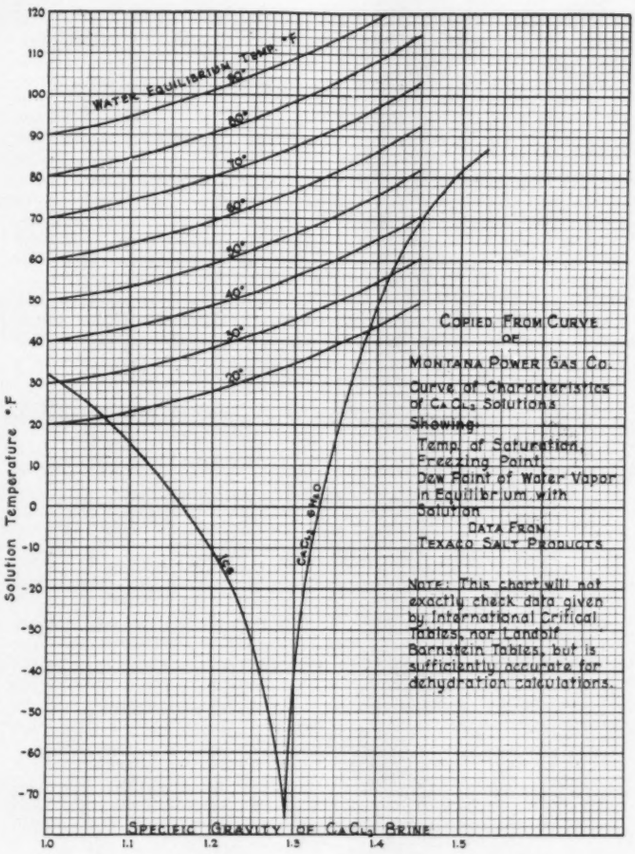


FIG. 3.


Water Equilibrium Temp. °F
Solution Temperature °F
Specific Gravity of CaCl2 Brine
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Montana Power Gas Co.
Curve of Characteristics of CaCl2 Solutions
Showing:
Temp. of Saturation, Freezing Point
Dew Point of Water Vapor in Equilibrium with Solution
Data From
Texaco Salt Products
Note: This chart will not exactly check data given by International Critical Tables, nor Landolt Barnstein Tables, but is sufficiently accurate for dehydration calculations.

FIG. 2.

and closes when the desired gravity is obtained. This flow is intermittent and is usually a small portion of the total circulation. The rate of flow over the concentrator may be varied or controlled so as to obtain the rate of evaporation which will maintain a smooth operation of the system as a whole.

From the surge tank the brine is pumped into the top of the contact tower where it flows down through a series of four bubble plates in contact with the upward gas flow thus completing the operating cycle. The pumping rate is 5 gallons per minute.

For this particular installation it was desired to obtain a dew point depression in the gas of 20-25°F. To obtain this it was necessary to maintain the brine specific gravity from 1.34 to 1.40. Observation has shown that the results obtained follow very closely a theoretical graph which appears as Fig. 2.

A question naturally arises about the corrosive effect of calcium chloride brine on the various equipment, especially in the contact tower where high pressures are maintained. Observation has shown that little or no corrosion takes place where the brine is confined to an atmosphere of natural gas. It is only when in the presence of air that it is active in this respect. Obviously the system should be thoroughly cleaned out when inoperative during the summer months.

To obtain the best results from this dehydration system it is desirable to remove all entrained oils, liquids, etc., from the gas by means of proper scrubbers before the gas enters the dehydrating tower. This prevents placing an undue burden on the system, the collection of an emulsified oil scum in the surge tank, and the deposit of solid matters in the bottom of the contact tower.

A dehydration plant similar to our installation was made by the Montana Power Gas Co. on its 20-inch pipe line from Cutbank to Morel. Fig. 3 shows in graph form observed data in connection with this dehydrating plant during the year 1935. The atmospheric temperatures encountered at this Montana plant are much lower than those encountered at the Ventura plant. It may be observed that there were but three or four days during the year in which the dew point of the gas exceeded the temperature at which hydrates would commence to form. Similar data are being collected for the Southern California Gas Co. plant.

Locating Accidental Contacts on Cathodically Protected Pipe Lines

By H. J. KEELING
Southern Counties Gas Company

CATHODIC protection of pipe lines in urban territories is, in many cases, complicated by the existence of numerous hidden contacts with neighboring underground structures. If these are extensive bare water or gas distribution systems, the current drained from them through the contact with the protected pipe line will make it impossible to keep the line negative to the soil with any reasonable value of current.

The first and most important step in locating an unknown accidental contact or short circuit to a section of cathodically protected pipe line is the establishment of contact points at intervals of 500 to 1,000 feet. It is necessary to have at least three contact points between each short circuit in case there is more than one, in order to conclusively establish their existence.

Recently our company has successfully found and removed 12 such short circuits on a 12-inch pipe line located under heavy concrete pavement without the necessity of excavation other than that required for the separation of the line from the offending structure. This was made possible by the development of a rapid and inexpensive means of establishing test connections, or contact points on the drained pipe line.

A common method of making contact to a pipe line for test purposes is by pressing pointed metal rods down on the pipe through holes augered in the earth. We have found that contacts made in this way are likely to be very poor unless extreme care is used. A small amount of loose dirt dislodged when the probe is inserted in the hole is sufficient to give a false potential reading if the pipe surface is rusted or coated with paint or wrapper. In many cases it is extremely difficult when using this method to determine if the probe is actually in contact with the pipe, or if it is merely touching the soil at the bottom of the hole. If the same hole is used several times during a test, additional dirt is dislodged each time and it is soon necessary to clean out the hole in order to make good contact with the pipe line. We have found that solid connections welded or brazed to the pipe line are superior in all respects and we have abandoned the use of loose contacts for testing purposes. The cost of installing the welded contact points is soon offset by the saving in time after a few tests are made. The permanent contact points have a further advantage in that batteries or an electric welder may be easily attached to them for a test.

Fig. 1 shows a cross section through one of these contact points. It consists of a ¼-inch iron rod electrically welded to the pipe line, extending to the surface through a 2-inch hole filled with coal tar enamel. These rods are installed in the following manner:

After determining the location of the pipe line from maps or by using pipe locators, a 2-inch hole is drilled through the pavement and down to the pipe with a compressed air star drill. The loose dirt is blown out of the hole by means of a 1-inch pipe attached to the air hose. This air jet is also used to enlarge the hole in the dirt, or to work it sideways in case the drilled hole was not exactly over the center of the pipe. With the hole enlarged, a thin rod may be used as a probe to determine the size of the buried line as an aid to establishing its identity. At this stage, it is usually possible to illuminate the hole with a flashlight or with sunlight reflected from mirrors, and examine pipe surface if desired. Before the actual welding is done, all tar or rust must be cleaned from the pipe surface by the judicious use of the star drill, or by hand with a bar. This is necessary in order to provide good contact for the welding rod when striking the arc. Once the arc is established, all coating and scale will be blown aside.

Any convenient iron rod about ¼-inch in diameter may be used for the welded connection to the pipe line, but it should be tipped at the lower end with a 2- or 3-inch length of 5/32-inch coated electric welding rod. We have found that this tip is not necessary if the pipe surface is absolutely clean, and the current intensity high; however, to minimize the danger of puncturing the line, it is advisable to use the least current possible. The weld is made with the rod negative and the pipe line positive, using a current of about 150 amperes at 45 volts. The welding ground clamp is attached to an adjacent contact point on the pipe line, or to any other convenient ground connection. The welding operator is governed entirely by the sense of touch and the sound of his machine, since he cannot see the arc. The rod is cut 3 or 4 inches longer than the depth of the hole so that the upper end can be grasped easily with the welding clamp. The rods for all but very temporary contact points are taped to within 1 inch of the lower end with a weather-

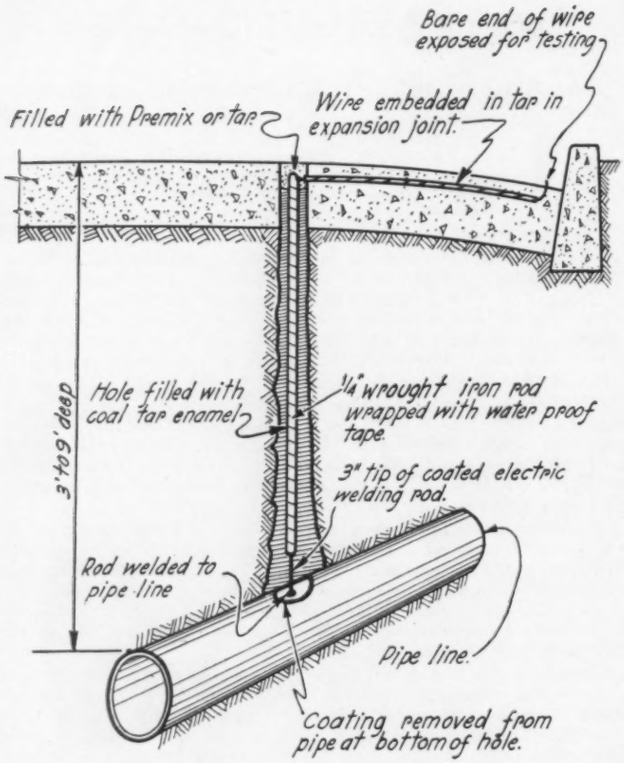
Bare end of wire exposed for testing
Filled with Premix or tar
Wire embedded in tar in expansion joint
3' to 9' deep
Hole filled with coal tar enamel
¼" wrought iron rod wrapped with water proof tape
3" tip of coated electric welding rod.
Rod welded to pipe line
Pipe line.
Coating removed from pipe at bottom of hole.

FIG. 1.

proof friction tape. This covering supplements the coal tar enamel and prevents the rod from touching the earth at the side of the hole in case it is not centered exactly. The prepared rod is dropped down the hole and then raised about half an inch while the welding clamp is attached, with the current turned on. The operator then lowers the rod and strikes the arc. The sound of the welding machine indicates to him when the rod is fused to the pipe line. When this occurs, the electrode is quickly unclamped from the contact point rod, or the circuit opened by having a helper remove the ground clamp. If the job is done correctly, the rod will be fused to the pipe line almost as soon as it touches, and the whole operation is completed in a few seconds. The connection is tested by pulling straight up on the rod. If this does not remove it, a good contact is assured, and the projecting end of the rod is cut off about ¼ inch or so below the surface of the pavement, then brazed over to provide a good connection for the test clips. If the rod can be easily pulled off by hand, it is necessary to try another weld. When attempting the second weld, it is advisable to move the rod over ½ inch or so; repeated arcs struck in the same place are likely to weaken or pierce the pipe line.

If the contact point is only to be used for temporary tests or very infrequent surveys, the upper end of the hole is filled with "premix" or soft road tar. This can be easily dug out when it is desired to attach a test clip to the upper end of the rod. The contact points for permanent use and frequent routine surveys have wires attached to them which are brought over to the curb. These contact points are usually located in the center of a tar-filled expansion joint in the concrete pavement so that it is easy to run the wire to the side of the road through the expansion joint. After brazing the wire to the iron rod, the tar is chipped out of the expansion joint to a depth of ½ inch or so, and the wire laid in the groove. Hot road tar is then poured back into the expansion joint so that the wire is held imbedded in place. The end of the wire next to the curb is stripped of its insulation for about an inch and the bare portion left projecting up through the tar. In this way the wire is easily available for test purposes without being conspicuous enough to attract the attention of inquisitive or mischievous persons.

Contact points of this kind have been installed on high-pressure gas lines ranging in diameters from 2 to 12 inches. While most of the connections have been put down through the surface of heavy concrete pavement, many satisfactory installations have been made on unpaved dirt roads. However, when the earth contained many rocks or boulders, we found it impossible to sink the hole with the star drill, and hand excavation was necessary.

It might be well at this point to discuss the likelihood of burning a hole in the pipe line when installing test connections by the method herein outlined. In developing this procedure, we experimented with various sizes and kinds of rods, and different intensities of welding currents. In one of the first installations, we operated the welder with reversed polarity, making the pipe negative and the rod positive. We had difficulty at this location in getting the pipe cleaned properly and struck the arc several times in an attempt to make the rod stick. We also boosted the current intensity to a high value. After about the third or fourth attempt, a hole was pierced in the pipe, a 12-inch high-pressure steel transmission line, and the gas was ignited by the arc. The flame issuing from the hole was very small, however, and easily snuffed out. Examination of the pipe later showed the puncture to be in the form of a small crater, with a hole at the bottom about 0.01 inch in diameter. This was easily patched without shutting the line down. Since this experience, we have installed over 200 similar contact points by the method described, and have not had a single subsequent case where the pipe was pierced. Some of the contact points have been installed on pipe lines buried 9 feet below the concrete pavement.

When the location of the pipe line is known, we are able to install three of these connections in about 20 minutes. This figure, however, does not include the time required to heat the tar and attach the wires, etc. During a test, it is possible to install additional points very quickly if they are needed. For temporary use, a rag is stuffed in the upper end of the hole to exclude dirt until it can be filled with enamel later.

The short circuits to the protected pipe line are located by establishing a potential gradient in the pipe by draining current at one or more points with batteries, electric welding machines, or other sources of direct current. The gradient will show an abrupt change in slope at the point where large values of current enter the pipe line through the short circuits. If a current is drained from the pipe line at two points, one on each side of a short circuit, the current entering the pipe through the accidental contact will be divided into two parts, each portion flowing in opposite directions along the pipe line to the drain points. The potential gradient resulting from these currents will take the form of two lines sloping downward in opposite directions from the short-circuited point to the two electrical drains. While two contact points on each side of the fault are theoretically all that is needed for the establishment of the direction of the slope of the potential gradient, it is advisable to use at least three on each side so that a check on the accuracy of the test will be possible. It is important to hold the currents constant so that the slope of the potential gradient will not change during the test.

The gradient in the pipe line is determined by measuring the potential drop between two adjacent contact points on the pipe line, using a potentiometer and a wire long enough to give measurable potential drops between the contact points. When making tests between points which are concealed by buildings or foliage, it is advisable to use portable telephones for communicating between the extremities of the test wire. If the telephone equipment is designed appropriately, it may be used in series with the single test wire and grounded return through the pipe line without interfering with the potentiometer readings. The potential at the contact points along the pipe line are plotted as points on graph paper using the millivolt readings as abscissas and the distance between the contact points as ordinates. If the currents drained from the pipe line have been high enough and the pipe line is all of uniform weight and size without insulators or couplings along its length, lines drawn between the plotted points should form two straight lines, which when extended will intersect at a point on the chart corresponding to the location of the fault. The smaller the angle between these two lines, the more accurately will the location of the short circuit be shown. Data plotted from tests made with contact points 500 feet apart will usually give the location of the short circuit within about 20 feet. If the pipe line lies beneath heavy concrete pavement where a minimum sized exploratory excavation must be used, it is advisable to install about three additional contact points about 20 feet apart on each side of the short circuit as located from the first preliminary test. Current is then drained from each side as before, except that readings are taken only between the new contact points. The large-scale potential gradient obtained from this second test will usually show the location of the hidden contact within 1 or 2 inches.

Fig. 2 shows the appearance of the graph for an actual preliminary test to determine the approximate location of a hidden short circuit to one of our 12-inch pipe lines located under heavy concrete pavement. The line was drained on the left by a cathodic protection station located about 600 feet to the left of the point represented by the origin of the graph. The drain on the right, consisting of an electric welder, was located at a contact point about 2,600 feet past the last point on the right-hand edge of the graph. The solid line connecting the potentials at the different points along the pipe line represents the potential gradient as measured between test connections. The dotted lines represent the actual gradient in the pipe line. The intersection point of these dotted

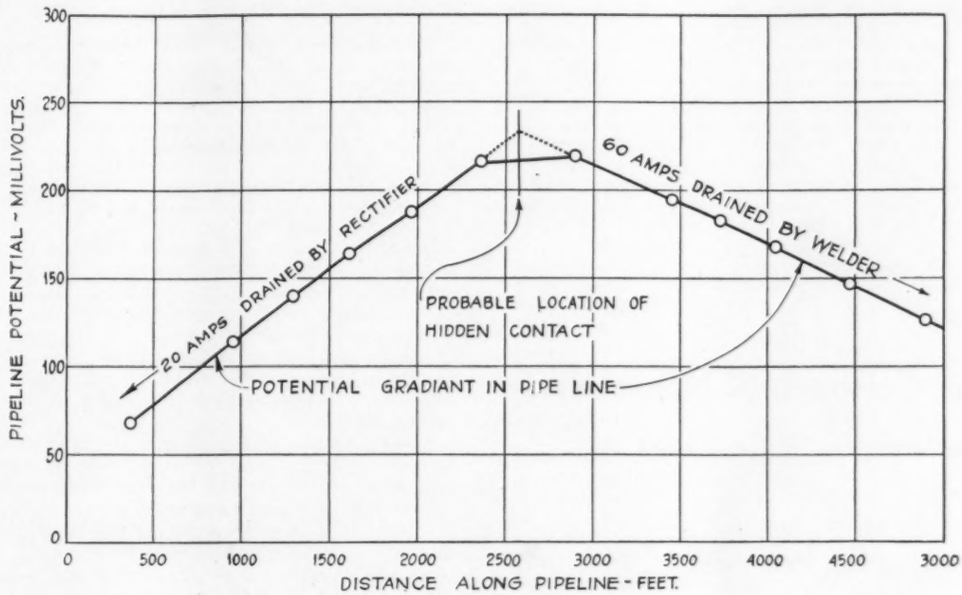
PIPELINE POTENTIAL - MILLIVOLTS.
DISTANCE ALONG PIPELINE - FEET.
20 AMPS DRAINED BY RECTIFIER
60 AMPS DRAINED BY WELDER
PROBABLE LOCATION OF HIDDEN CONTACT
POTENTIAL GRADIANT IN PIPE LINE

FIG. 2. Locating an accidental contact between a 12-inch pipe line and an unknown structure. First test to determine approximate location.

lines, the highest point on the curve, gives the location of the point on the pipe where current is picked up through the short circuit.

Having established the location of the fault within 10 or 20 feet, the next step was to install six temporary test connections, three on each side of the approximate location of the short circuit. For this second test, the welding machine was moved closer to the fault so that a steeper potential gradient would be produced. The resultant curve is shown in Fig. 3. The data indicated that the location of the hidden connection was about 7½ feet to the right of the contact point on the 50-foot mark. A hole 2 feet square cut in the pavement at the indicated location of the fault showed that the pipe line was in contact with a bare copper water service.

In certain cases where the fault has been located within 20 or 30 feet, the circumstances may make it impossible to install the required additional test connections close to the short circuit for a second test. If such is the case, it is still possible to locate the hidden connection using only a pair of contact points a few inches apart on each side of the short circuit. This method is illustrated by Fig. 4. A battery or other source of direct current is attached

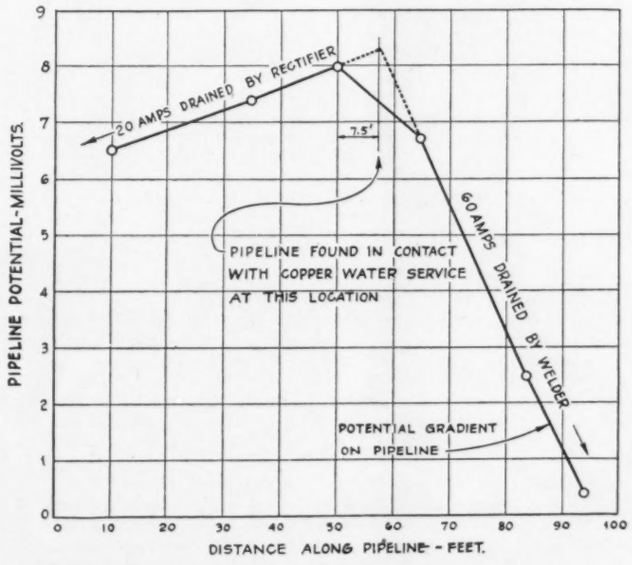
PIPELINE POTENTIAL-MILLIVOLTS.
DISTANCE ALONG PIPELINE - FEET.
20 AMPS DRAINED BY RECTIFIER
7.5'
PIPELINE FOUND IN CONTACT WITH COPPER WATER SERVICE AT THIS LOCATION
60 AMPS DRAINED BY WELDER
POTENTIAL GRADIENT ON PIPELINE

FIG.3. Locating an accidental contact between a 12-inch pipe line and an unknown structure. Final test made after installing more contact points to determine exact location.

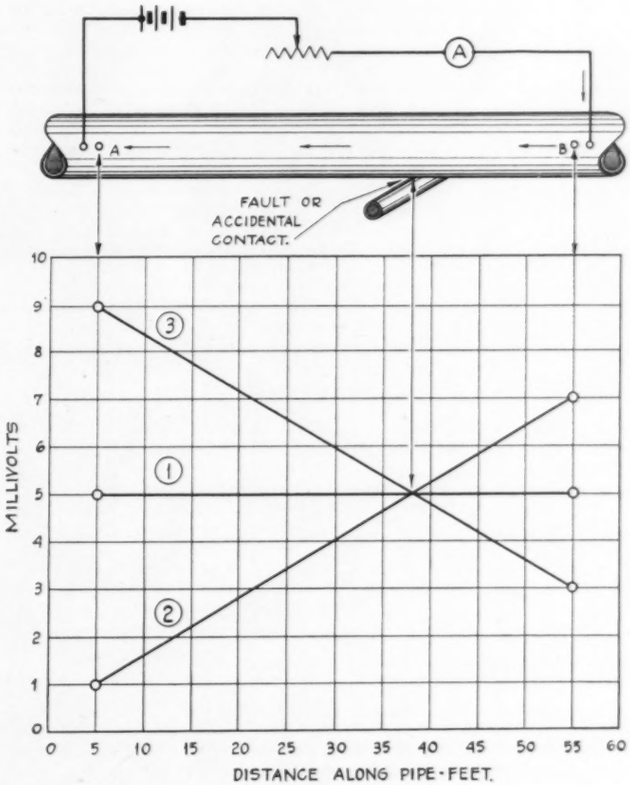

FIG. 4. Diagram of second method for locating a hidden contact to a pipe line.

to the outside points of the two pairs of test connections on the pipe line so that the current flowing through it will produce a potential gradient. Since this current flows only along the pipe line and not through the accidental contact, the potential of the pipe line at the point where it is short circuited will always remain the same as the potential of the structure it is touching. The potential at each point A and B on the pipe is measured through the second set of contact points. It is necessary to use this second set of test connections in determining the pipe potential because

the potential drop through the small rods carrying the current to the pipe will be indeterminate. All potentials should be measured with reference to a driven rod or a non-polarizing electrode located several hundred feet away from the pipe line where it is unlikely to be affected by transient currents in the soil. Curve 1 in Fig. 4 shows the potential gradient in the pipe before the current was applied. Curve 2 shows the gradient resulting when the positive battery terminal was attached at A and the negative terminal at B. Curve 3 shows the potential gradient when the direction of the current flowing in the pipe was reversed. Additional curves may be obtained by using several values of current. All the potential gradients will intersect at a common point representing the potential and location of the fault.

We have successfully used this method in locating a short circuit under conditions where it was not possible to find it in any other way.

The Internal Corrosion of Natural Gas Transmission Pipe Lines

By M. T. BURTON

Southern California Gas Company

THIS paper will be limited to a consideration of the specific problem of the internal corrosion of natural gas and oil lines. The transmission and distribution of manufactured gas has always been complicated by the presence in the gas of such corrosive constituents as carbon dioxide, oxygen, water, hydrogen cyanide, hydrogen sulphide, and other sulphur compounds. Fortunately, natural gas supplies have been relatively free from excessive quantities of corrosive constituents, with the exception of so called "sour fields" in certain localities such as New Mexico and West Texas, where large quantities of hydrogen sulphide have been encountered.

For many years the California fields were thought to be particularly free from hydrogen sulphide corrosion with the notable exceptions of the Maricopa, Fellows, McKittrick and some few other districts.

The first case of serious internal corrosion occurring in Southern California of which the author has knowledge, occurred in the transmission lines of the Midway Gas Co. operating in the Inglewood oil field. A study of the internal corrosion (1) conditions in this field was presented before this Association in a previous paper.

Since that time several papers have described internal corrosion conditions in the Huntington Beach, Ventura, Venice and Kettleman Hills fields. (2), (3), (4). A separate committee of this Association on internal corrosion has been active since 1932.

The outstanding feature of nearly every case studied in Southern California was the extremely low concentration of H_2S present, the only exception being in the Venice field where the sulphur concentrations are rather large. Generally, however, the concentration may be expressed in fractions of grains per 100 cu. ft.

Further, serious corrosion has never been known in lines operating at less than 3 or 4 atmospheres pressure.

From the Inglewood study the author concluded that:

1. Internal corrosion in the natural gas lines in the Inglewood Oil Field is caused by hydrogen sulphide in water solution, and also by sulphuric acid formed from H_2S.

2. High pressure, through the greater solubility and solution rate of gaseous oxygen in the corroding medium, under increased partial pressure, with consequent depolarization of iron is the controlling factor.

3. Corrosion increases generally in proportion to increased partial pressure of oxygen with increasing total pressure. Corrosion rises to maximum, falls off, and remains fairly constant.

4. Dehydration and purification are shown through experimental evidence obtained as nearly as possible under actual working conditions to practically eliminate corrosion.

A further study of internal corrosion was undertaken in this laboratory during the past year and a series of laboratory corrosion tests were made to determine the probable effect of the various factors controlling the rate of corrosion.

It was realized that short time laboratory corrosion tests are subject to certain inherent weaknesses and that the results obtained could not be taken too literally nor too definite conclusions drawn as to the life of steel pipe lines in service conditions.

Such tests do, however, give a relative comparison of the various factors on the initial corrosion rate of clean oxide-free steel and therefore would be of value.

The apparatus used is shown in Fig. 1 and is much like that used by Wilhelm Schmidt and Devine (5) in a somewhat similar investigation. The apparatus differs principally in that provision is made for the control of the humidity of test gas to any desired degree by controlling the temperature of saturation and maintaining a constant temperature on the corrosion test chamber.

Three constant temperature baths are used with a mixture of light lubricating oil and kerosene for the bath liquid .

Agitation of the baths was accomplished by the use of small 110-

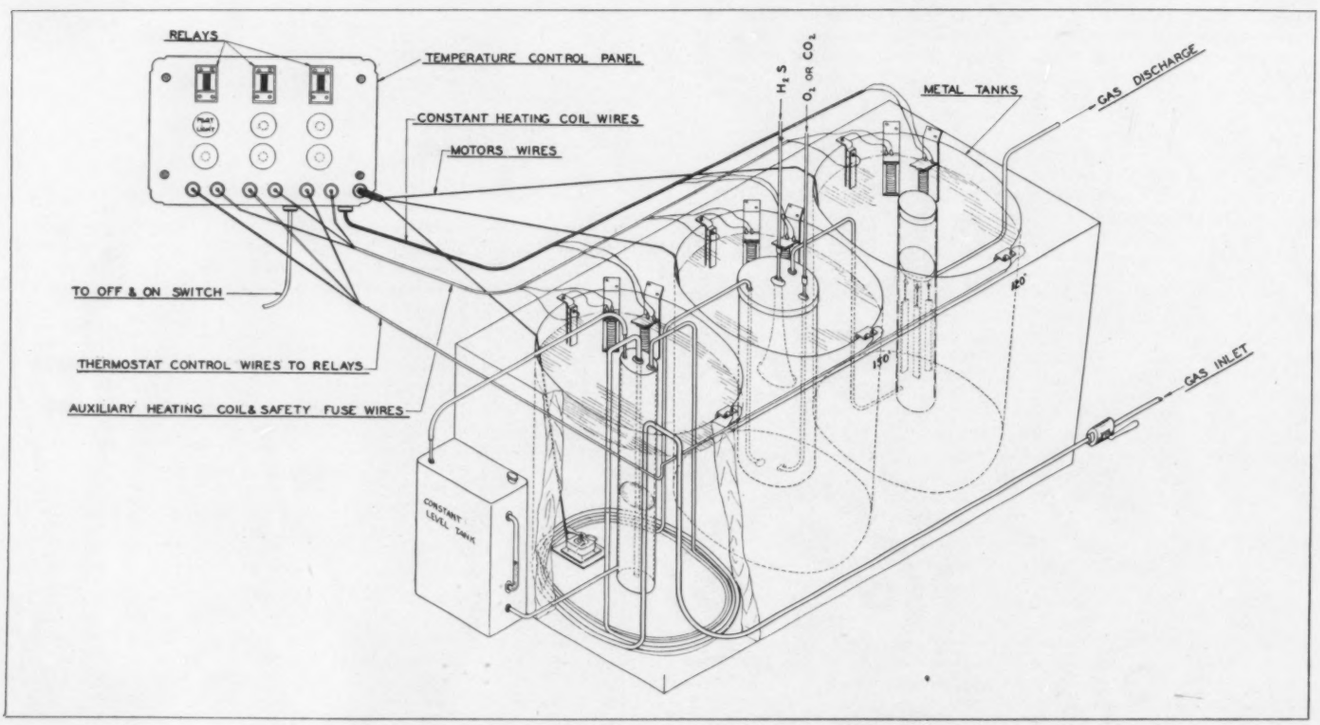

FIG. 1. Internal corrosion test setup.

TABLE NO. 1. LABORATORY CORROSION TESTS OF STEEL.

Using Hydrogen Sulphide, Carbon Dioxide, and Oxygen and Pipe Corrosion Products at Atmospheric Pressure.

Test No.	Relative Humidity %	O_2 %	O_2 Equivalent % at 28 Atmospheres	H_2S Grains per 100 Cu Ft.	H_2S Equivalent Gas at 28 Atmospheres	CO_2 %	CO_2 Equivalent % at 28 Atmospheres	Corrosion Loss in Wt. Ozs. per Sq. Ft. per Year
1	132.0	0.00	0.00	0.00	0.00	0.00	0.00	.304
2	75.3 to 132.0	5.86	0.21	100.00	3.55	0.00	0.00	.644
3	132.0	5.86	0.21	100.00	3.55	0.00	0.00	9.320
4	75.3	5.86	0.21	100.00	3.55	0.00	0.00	.209 *
5	75.3	5.86	0.21	100.00	3.55	0.00	0.00	.162 *
6	132.0	0.00	0.00	100.00	3.55	0.00	0.00	.675
7	132.0	5.86	0.21	0.00	0.00	0.00	0.00	3.140
8	132.0	21.00	0.75	0.00	0.00	0.00	0.00	6.250
9	75.3	21.00	0.75	0.00	0.00	0.00	0.00	.290
10	132.0	0.00	0.00	0.00	0.00	100.00		.000
10A	Liquid H_2O	0.00	0.00	0.00	0.00	100.00		2.980
13	132.0	2.02	.07	0.00	0.00	6.40	0.22	.175
14	132.0	2.02	.07	?	?	6.40	0.22	1.680
15	132.0	3.94	.14	?	?	12.50	0.45	1.400
16	132.0	3.94	.14	?	?	12.50	0.45	.540
17	132.0	3.94	.14	1.89	.067	12.50	0.45	2.050
18	132.0	3.94	.14	0.00	0.00	12.50	0.45	.500
19	132.0	3.94	.14	0.00	0.00	0.00	0.00	1.450
20	100.0	0.00	0.00	100.00		0.00	0.00	.715
21	100.0	100.00		0.00		0.00		.700
22	100.0	100.00		0.00		0.00		.860
22A	Liquid H_2O	100.00		0.00		0.00		12.700
23	132.0	3.94	.14	0.00	0.00	0.00	0.00	1.330**
24	132.0	.50	.018	0.00	0.00	0.00	0.00	18.500†
25	75.3	.50	.018	0.00	0.00	0.00	0.00	Trace‡

*Duplicates
**Duplicated No. 19
†Corrosion Products
‡After 1 week

volt induction motors designed for oil immersion. The motors were fitted with three blade impellers.

Electric lamps were used as short lag immersion heaters and were controlled by sensitive bi-metallic thermostats and Leach relays. In this manner excellent temperature control was obtained.

The first bath contained coils of copper tubing and a constant level saturating tube and liquid trap so that the purified natural gas used for the test could be saturated without the entrainment of free water.

The second bath likewise contained copper tubing coils and a large volume pyrex glass mixing chamber where any desired corroding agent could be introduced. This bath operated at a much higher temperature than the saturating bath and thus imparted a superheat to the gas so as to prevent deposition of liquid water.

The gas was then passed through a short length of 2 mm. capillary glass tubing to the corrosion chamber in the third bath.

The third bath was held at a constant temperature of 120° F. throughout the entire series of tests, thereby controlling the reaction temperature. The relation of the saturation temperature to the reaction temperature determined the degree of under or over saturation and simulated one factor encountered in actual pipe line condition.

Oxygen and carbon dioxide were measured through small glass flow meters calibrated against laboratory test meters. The natural gas was introduced at a definite pressure and the flow rate checked from time to time by the same type of meter. The flow remained very constant throughout each run.

Hydrogen sulphide at the larger concentrations was introduced by diffusion at constant pressure through thin gum rubber membranes (18) and the amount checked by the precipitation of cadmium sulphide and iodometric titration in hydrochloric acid solution. The concentration remained generally constant throughout with the exception of three runs, Nos. 14, 15 and 16, where some condition of the rubber membrane cut the concentration of H_2S to some unknown value. The tests during these runs were included, however, to show the effect of a small quantity of H_2S.

The smaller concentrations of H_2S used in run No. 17 was injected through a small glass orifice at constant pressure by equalizing the pressures on the H_2S generator and mixing chamber. The concentration was checked by the recently developed H_2S Photocolorimeter and remained very constant. (6).

The corrosion chamber was blown from 65 mm. pyrex tubing with inlet and outlet tubes below the bath liquid level. A rubber stopper could be placed at any point within the tube, effectively limiting the test atmosphere to the space below the liquid level of the bath, thereby preventing deposition of liquid during tests at under-saturation.

The steel test specimens were cut from bar stock and were 1/16- by 1- by 6-inch. Each specimen was polished by fine emery paper, washed in alcohol and petroleum ether and weighed. Four specimens were used and the average weight loss taken.

After each test the corrosion products were removed by a short immersion in a 1 per cent solution of ammonical ammonium citrate and the loss in weight noted.

It was desired to make the test period as long as possible so each run was of a seven days duration.

The results are shown in tabular form in Table No. 1.

On the assumption that the accelerating effect of pressure might be due to the increase in effective concentration of the corroding media, the concentrations are calculated to a basis of 28 atmospheres and are shown beside the actual concentrations.

For purposes of comparison, the weight losses are calculated to ounces per square foot per year. It is understood, however, that these rates are purely comparative and show only the initial rates to be expected under these conditions.

For the purpose of discussion, some generalizations, subject where necessary to later restatement, may be drawn from these data.

1. Natural gas containing free entrained water at normal temperatures is not corrosive to steel in the absence of oxygen, hydrogen sulphide or carbon dioxide. Test 1.

2. Natural gas considerably under-saturated but containing both H_2S and oxygen is not corrosive to clean oxide-free steel, while the same gas is very corrosive if over-saturated. Tests 3, 4, and 5.

3. Natural gas containing hydrogen sulphide is much less corrosive than the same gas containing oxygen. Tests 3 and 6.

4. Natural gas containing oxygen, if oversaturated, is corrosive even in the absence of hydrogen sulphide or carbon dioxide. Test 7.

5. Atmospheric air is of itself very corrosive to steel if oversaturated but is not corrosive considerably below saturation. Tests 8 and 9.

6. Natural gas containing hydrogen sulphide and oxygen is relatively corrosive to steel in proportion to time of over- to under-saturation. Tests 2 and 3.

7. Pure carbon dioxide oversaturated is not corrosive to steel. Test 10.

8. Carbon dioxide in natural gas is apparently of much less importance than hydrogen sulphide or oxygen. Tests 13, 14, 15, 16, 17, 18 and 23.

9. Pure H_2S or oxygen at saturation is corrosive to clean, bright steel but either oxygen or carbon dioxide is much more corrosive in the presence of much water than at saturation or in the presence of little water. Tests 20, 21, 22, 22A and 10A.

10. The products of corrosion removed from a pipe line are of themselves very corrosive in the presence of liquid water and a trace of oxygen and may even become somewhat corrosive at below saturation. Tests 24 and 25.

Some of the statements require some further explanation at this point, i.e.:

No. 6. The gas in Test 2 was maintained in an undersaturated condition approximately 90 per cent of the time and in an oversaturated condition for the remaining period, while the gas in Test 3 was oversaturated throughout the test. Under these conditions the loss of .644 oz. per sq. ft. per year in Test 2, while in Test 3 the loss was 9.320 oz., the ratio of loss being 14.4 instead of the theoretical 10. However, as the time of under- and oversaturation could only be maintained approximately, the results are in fair agreement.

No. 8. The runs containing only a small volume of oxygen and a considerable amount of carbon dioxide show much less corrosion than do those containing the same amounts of these agents with the addition of even a small amount of H_2S.

No. 9. Test 20 was made by passing a very slow stream of pure H_2S through a small amount of distilled water placed in the bottom of the corrosion chamber with the chamber being stoppered above the bath level, allowing some condensation over the specimens.

The same procedure was followed with pure O_2 in Tests 21 and 22, while in 22A and 10A, 2-inch steel discs were placed in the water in the bottom of the corrosion chamber.

In Test 20, the test specimens were immediately blackened and when removed were covered with a smooth, evenly-distributed, closely adherent film of brownish-black iron sulphide.

Tests 21 and 22, on the contrary, showed no tarnishing of the steel for fully 48 hours and then only where droplets of free water condensed from above the bath line fell on them. Upon removal scattered patches of bright red rust were found underlain by very definite pitting. A large portion of the surface of each specimen remained clean and bright. Evidently, the *initial* oxygen corrosion of iron definitely requires the presence of free water and rust apparently has the ability to absorb or adsorb water from a saturated atmosphere.

Test 22A showed immediate action and it will be noted that the ratio between 22A and 22 is 14.8. Test 10A shows that carbonic acid in the absence of air or any other corrosion agent is somewhat corrosive to steel.

No. 10. Test 24 shows the highest corrosion rate of any test conducted and definitely shows the corrosive character of the corrosion products. Test 25 shows only a trace of corrosion in one week's exposure but there is other evidence to show that in time the scale could absorb sufficient water from an undersaturated gas to become corrosive.

Since the publication of the author's original paper, other investigators have likewise studied internal corrosion, particularly that due to hydrogen sulphide. The results of some of this work will now be discussed.

One group (7) of investigators has noted that as little as 0.10 per cent H_2S in the presence of air and water has caused the failure of steel oil tank roofs in less than three years and has doubted that sulphuric acid as an oxidation product of H_2S is frequently the cause of corrosion. They cite the general equation $SO_2 + 2\,H_2S = 3\,S + 2\,H_2O$ to show that any possible sulphuric acid produced would be immediately reduced to free sulphur and water and therefore could not react with the steel.

They agree, however, that sulphurous or sulphuric acids can be and are produced when a metal which has been corroded by H_2S, air and water is removed from contact with the H_2S. Under these conditions the remaining products of corrosion oxidize to iron sulphite and sulphate; these are hydrolyzed by water to form sulphurous and sulphuric acids. They also show that the acids in turn react with the metal, are again and again hydrolyzed, thus causing a continuous corrosion cycle.

The fact that sulphuric acid had actually been found in drip water removed from an actively corroding pipe line indicated that some sulphuric acid must be able to exist in the presence of H_2S.

In a laboratory test, solutions of N/100 H_2SO_4 and N/10 H_2SO_4 were treated with pure H_2S in the absence of air for a period of 72 hours after which the solutions were boiled to expel any absorbed H_2S and then titrated.

The strength of both solutions remained absolutely unimpaired, proving that sulphuric acid in considerable concentration can exist without reduction, in the presence of any possible concentration of H_2S.

Concentrated H_2SO_4 on the other hand is immediately reduced to free sulphur and water.

The explanation is simple in that in dilute solution H_2SO_4 is so completely ionized as to reduce the (S^{--}) ion concentration from the H_2S to so low a value that reduction of the H_2SO_4 is impossible. The concentrated acid, however, is only slightly ionized so that the S^{--} (sulphide) ion can exist in sufficient concentration to cause reduction.

The role of sulphuric acid will further be considered in a later section.

Wilhelm Schmidt and Devine (5) have studied the effect of oxygen on the gaseous hydrogen sulphide corrosion of tank steel and have described an apparatus and method for the laboratory testing of H_2S corrosion at atmospheric pressure and saturated humidity conditions.

They have concluded that:

1. Oxygen is necessary to cause corrosion.

2. The oxygen hydrogen sulphide ratio in the gas is the prime consideration in predicting the magnitude of the corrosion. The apparatus showed that when the ratio was approximately 114 the maximum corrosion was reached.

3. Cases of relatively low hydrogen sulphide content are more active in producing corrosion in the presence of a small amount of oxygen than are gases containing a relatively large amount of H_2S. However, it appears that approximately .025 per cent H_2S (16 grains per 100 cu. ft) is the lower limit for producing severe corrosion at atmospheric pressure.

4. Corrosion proceeds proportionately with the time, denoting that the scale formed on the metal in these tests is of a non-protective character.

Their first conclusion is so generally accepted as to be axiomatic and needs no discussion.

The oxygen-hydrogen sulphide ratio is an interesting relationship and other factors remaining constant would probably control the *initial* corrosion rate at increased pressure as well as at atmospheric pressure.

The third conclusion likewise holds to a limited extent. It appears, however, that the threshold concentration of 16 grains per 100 cu. ft. for serious corrosion is much too high. In the Inglewood study, the maximum corrosion found occurred at a line pressure of 120 lbs. and an H_2S concentration of .11 grains per 100 cu. ft. and .10 per cent O_2.

Assuming that the corrosion rate increases as the effective concentration of H_2S, the total would be .99 grain at 120 lbs. gauge pressure or slightly more than 6 per cent of the 16 grains.

In another line in the same field operating at 20 lbs. gauge or 35 lbs. absolute, the concentration was .79 grain and the effective concentration at 20 lbs. gauge 1.8 grains. In this line no corrosion was ever found.

The corrosion rate, all factors remaining constant, is undoubtedly a linear function of time for some indeterminate period of initial corrosion, but as before noted, it is somewhat dangerous to assume, on the basis of laboratory corrosion tests, that it would remain so indefinitely. The authors themselves recognized and stated the inherent weakness of such tests but believed that where the initial rates are not far from ultimate, the tests would be of service.

That the apparent corrosion rate, even if determined under actual pipe line operating conditions, varies tremendously with the time of exposure is shown in Table No. 2.

These data were obtained by the insertion of weighed steel coupons into the center of the gas stream. The coupons were cut from sections of the same pipe metal and were inserted through the device shown in Fig. 2.

With the exception of No. 2, the longer exposure periods indicate a much greater corrosion rate than do the shorter periods.

The corrosion rate from these coupons does not necessarily show the true corrosion rate for the pipe at the time but does show that after some initial period of corrosion the rate may become accelerated. This will be further covered in a later section.

These same investigators (8) have likewise studied the corrosion of steel by quantities of H_2S less than 13 grains per 100 cu. ft. and have attempted the correlation of the effect of the various factors of concentration of corroding substances, pressure and moisture conditions.

Two forms of corrosion are described, the first in which the surface of the metal is believed to be "essentially" dry is termed ordinary gaseous corrosion, while the second called modified gaseous corrosion requires the presence of an appreciable visible film of water.

The first type is thought to be a direct chemical attack, while the second is electro-chemical in nature.

TABLE NO. 2. CORROSION RATE OF STEEL TEST COUPONS EXPOSED IN PIPE LINES.

No.	Time Exposed Months	Loss in Oz. per Sq. Ft. per Yr.
1	3.0	.16
	4.5	.29
	11.0	.28
2	3.0	1.49
	4.5	1.71
	11.0	.56
3	3.0	.23
	5.0	2.14
	11.0	.74
4	4.5	.27
	11.0	.41
5	3.0	.05
	4.0	.01
	4.5	2.32
6	4.0	.03
	4.5	.09
7	4.0	.03
	11.0	.05

Just what would differentiate the direct chemical and electrochemical corrosion of iron is not entirely clear.

The work of Evans (9) on the mechanism of hydrogen sulphide corrosion of copper is cited. Evans concluded that in the presence of little moisture, the attack on copper is directly chemical while in the presence of a definite liquid film the attack is electrochemical.

The work of Lilienfield (10) and White on the hydrogen sulphide corrosion of metallic silver offers a logical explanation of the corrosion of both silver and copper.

They concluded that both water and oxygen are necessary to produce corrosion of silver at room temperatures and show that elemental sulphur and metallic silver do react readily at room temperatures with the production of silver sulphide. Therefore, they reasoned that a reaction between H_2S and oxygen might proceed thus: $H_2S + \frac{1}{2} O_2 = S + H_2O$ and that the nascent sulphur produced would react directly with the silver.

The position of both copper and silver below hydrogen in the electromotive series of metals indicates the strong probability of such a reaction.

Iron, on the contrary, occupies a position far above hydrogen so that it is difficult to imagine any direct reaction between iron and elemental sulphur at normal temperatures to produce iron sulphide.

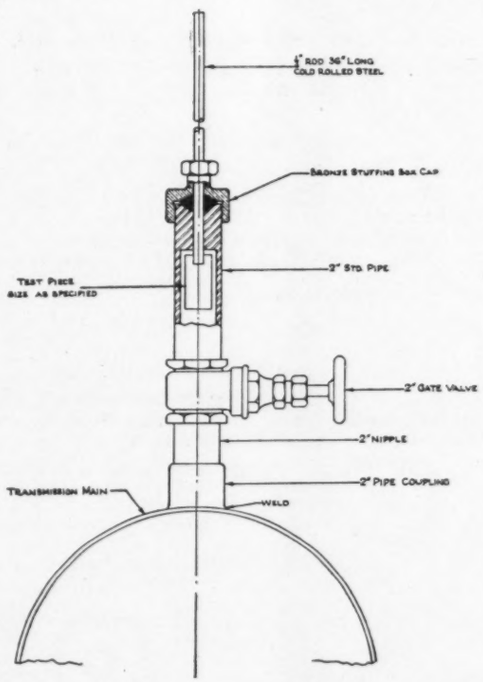

FIG. 2. Device for installing corrosion test specimens in pipe lines.

Elemental sulphur can, however, in the presence of water and oxygen, be directly corrosive to iron by the oxidation of sulphur to sulphuric acid and also by cathodic action.

The accelerating effect of pressure on the corrosion rate was also noted by these investigators and was explained as owing its chief effect to a concentrating action on the corrosion media.

As before noted, however, cases of severe corrosion have been known where the effective concentration of H_2S was less than half that found in lines where corrosion was not present.

That an increase in pressure results in a greater effective concentration of oxygen and hence an increase in corrosion rate is merely another way of expressing the second conclusion in the author's original paper.

The work of numerous other investigators (11) (12) (13) leaves little doubt that the action of oxygen is generally one of depolarization, although it is entirely probable that certain areas of a corrosion medium might show preferential solution rates of oxygen due to certain conditions, i.e., thickness of corrosion film, etc., and thus give rise to oxygen concentration cells.

The actual mechanism of internal corrosion is shown by all available data to be exceedingly complex and probably varies for each specific case.

For the formulation of a reasonably satisfactory concept of the probable general mechanism of corrosion we shall necessarily assume a set of ideal conditions.

Let us then assume that a newly installed pipe line is rust free on the internal walls and that it is carrying at some pressure a potentially corrosive natural gas containing hydrogen sulphide, carbon dioxide, oxygen and water vapor.

Under some condition or conditions this gas may become corrosive. It has been shown that a gas though potentially corrosive is not actively corrosive to clean rust free steel if the gas is considerably undersaturated.

To initiate corrosion a sensible film of liquid water must be precipitated, usually by cooling of the gas below its dew point.

With liquid water present the corroding agents dissolve in the water. Hydrogen sulphide in water solution forms a weakly ionized acid and dissociates to form hydrogen and sulphide ions.

Iron having a definite solution pressure tends to go into solution and reacts directly with H_2S in solution to form iron sulphide and hydrogen.

In solutions of weakly ionized or very dilute solutions of non-oxidizing acids, the solution or corrosion of iron is quickly reduced to a minimum due to the formation of a film of electrically neutral mon-atomic hydrogen or is in other words, polarized. The hydrogen can, however, be removed as formed by dissolved oxygen so that the corrosion rate will become dependent upon the amount of dissolved oxygen.

As earlier noted, dissolved oxygen is of itself corrosive to iron and may react in the presence or absence of other agents. Therefore, two initial reactions may take place simultaneously.

1. $Fe + 2\,H^+ + S^{--} + \frac{1}{2}\,O_2 = Fe\,S + H_2O.$
2. (a) $Fe + 2\,H^+ = Fe^{++} + 2\,H$ (atomic)

   $2H$ (atomic) $+ \frac{1}{2}\,O_2 = H_2O$ (14)

Immediately that corrosion is initiated, corrosion products appear and secondary reactions may take place. These secondary reactions are governed to a large extent by the amount of oxygen present.

The amount of oxygen which can be dissolved by a unit quantity of water depends upon the partial pressure of the oxygen (Henry's Law) and the rate of solution depends upon the solubility, the degree of oxygen concentration and the amount of agitation at the water surface.

The rate of diffusion of dissolved oxygen through a liquid film is directly proportional to the oxygen concentration and inversely to the film thickness.

The atmosphere within a pipe line through which gas is flowing is always in a state of turbulence so that it is evident that the condensed water would very quickly reach equilibrium with the oxygen in the gas.

The ionic iron formed in equation No. 2 usually reacts with additional oxygen to precipitate iron oxide or may also partially react with H_2S to form additional FeS.

Some H_2S may be oxidized directly to H_2SO_4 or some of the FeS may be oxidized to $FeSO_4$, which subsequently hydrolyzes with water to form H_2SO_4. In any event sulphuric acid is formed which may change conditions materially. The sulphuric acid may react directly with the iron to form iron sulphate; again hydrolyze and repeat the process.

A second and important effect of the presence of H_2SO_4 on the corrosion reaction is that of the suppression of the ionization of hydrogen sulphide and carbon dioxide in solution.

Hydrogen sulphide in water solution forms a di-basic acid which is only very slightly ionized according to the following equation:

$$\frac{(H^+)^2 \times S^{--}}{H_2S} = 1.1 \times 10^{-23}$$

Here we see that the sulphide ion concentration is inversely proportional to the square of hydrogen ion concentration or pH and that a slight increase in the pH value from some other source must result in a very large decrease in the sulphide ion concentration.

The concentration (15) of the dissolved non-ionized H_2S is practically a constant if solutions saturated with H_2S under a given pressure are considered.

In a saturated water solution at 25° C or 77° F and atmospheric pressure the concentration of H_2S is approximately .10 molar or .20 normal.

If by some means a dilute solution of H_2SO_4 is formed the acid may be considered completely ionized.

A solution of N/100 H_2SO_4 shows a hydrogen-ion concentration approximately 100 times that of the saturated H_2S solution. Therefore, as the sulphide ion is inversely proportional to the square of the pH concentration the S^{--} concentration is decreased 10,000 times.

In like manner carbonic acid being also a very slightly ionized acid the carbonate-ion is tremendously decreased by the presence of even a trace of H_2SO_4. This probably explains to some extent the absence of any material quantity of carbonates in the corrosion products in most cases.

The concentration of .1 molar or .2 normal H_2S given above is of course merely explanatory and probably could never be reached in actual field conditions while it is entirely probable that solutions of N/100 H_2SO_4 could be produced in a pipe line due to the concentration of corrosion products.

In most cases of internal corrosion some elemental sulphur is formed which may be oxidized to H_2SO_4 or cause rapid pitting due to cathodic action.

Further, iron sulphide and iron oxide are likewise cathodic to steel and may cause corrosion, galvanically.

Iron oxides formed in the absence of silicates or other cementing agents usually form a porous mass instead of a continuous coating and quoting Andes—(16):

> "All porous bodies without exception are endowed with the property of condensing or occluding gases in their capillaries. Iron rust being porous, we may assume the presence of condensed oxygen in the rust pores. Moreover, rust has the power of absorbing (or adsorbing) and retaining water and since this water will dissolve the condensed oxygen present in the pores, we may regard the liquid retained by iron rust as a concentrated aqueous solution of oxygen."

The corrosion products formed, i.e., iron sulphide, iron oxides, iron sulphate, elemental sulphur and sulphuric acid are all corrosive in the presence of water and oxygen. Also some corrosion products evidently have the power of removing water from a gas at or near saturation.

This absorption was demonstrated in the laboratory tests using pure oxygen at saturation, and together with the accelerated corrosive power of the corrosion products, accounts for the continued corrosion appearing on the coupons Nos. 3 and 4, Table No. 2, where the gas had been dehydrated by atmospheric cooling and was somewhat below saturation, and likewise accounts for the corrosion in Case No. 7 which is over 30 miles distant from the last compressor station and could only retain the smallest trace of H_2S, and could not possibly be oversaturated.

We find therefore that the initial corrosion rate and the ultimate rate may be and generally are very different and that a pipe line transporting gas containing even small quantities of corrosive constituents may eventually become severely corroded due to concentration of corrosion products.

SUMMARY AND CONCLUSIONS

In this paper are presented the results of a study of internal corrosion based on laboratory and field data. The following conclusions are offered, based upon the foregoing study.

1. (a) Natural gas in the absence of hydrogen sulphide, oxygen or carbon dioxide is non-corrosive to steel even in the presence of liquid water.

(b) Natural gas containing hydrogen sulphide and/or oxygen or carbon dioxide is corrosive in the presence of liquid water.

2. The initial corrosion of rust free steel requires the presence of a sensible film of liquid water.

3. The products of internal corrosion are of themselves corrosive to steel in the presence of liquid water.

4. The products of corrosion may absorb or adsorb some water from a gas at or near saturation and may therefore cause corrosion when the gas is undersaturated.

5. The corrosion rate generally accelerates from the initial to the ultimate rate.

6. Corrosion may be decreased or eliminated by

(a) Dehydration to considerably under saturation (75 to 80 per cent relative humidity).

(b) Complete removal (17) of the products of corrosion from the pipe line.

(c) Complete or partial removal of hydrogen sulphide and oxygen.

(d) Installation (1) of oil sprays to coat the surface of the internal pipe wall.

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Current Practice and Trends in Orifice Metering*

IN JANUARY of this year the Pacific Coast gas companies started using the "Tentative Standard Procedure for the Measurement of Natural Gas with Orifice Meters,"† based on the new A.G.A. coefficients.

We were provided with the necessary coefficients and factors for calculating the flow of gas under any condition. The joint committee which compiled the report made several improvements on the procedure and presented us with a very workable set of tables. Not included however, was any standard procedure for the collection of temperature, specific gravity and other data which are used in the calculation of coefficients. The committee recognized the need for this, but soon found that any efforts along this line would greatly delay the release of the new coefficients.

As a result we still have wide variations in methods of collecting data and applying it to the coefficients. Revisions are made over almost any period from hourly on up. Each company has developed its own variations in procedure to fit its previous conditions of practice, personnel, and equipment.

The present P.C.G.A. Committee has collected data on methods that have been developed among the member companies, in an endeavor to find out what could be done in the way of simplification and standardization. Analysis of the results indicates that there are at present so many influences causing variations in procedure that any agreement on standard methods would be very difficult.

The following material has been collected with the intention of analyzing present practice, and also of gathering opinion as to the quality of present results and the desirability and direction of further improvements.

From this, a summary of the ideas that are most desirable may be selected and improved upon. The problem of standardization and general adoption will be greatly simplified if still better methods can be developed which are outstandingly superior for all ranges of conditions.

The Expansion Factor is being applied as a multiplier in the coefficient on all but four meters. These latter four installations use the intermediate pressure device and are more or less experimental. Some companies revise the multipliers daily, weekly, or monthly. Others review the factors at similar intervals and revise if the variation exceeds a certain value, such as .1 per cent. The Reynolds and Expansion factors are frequently combined and sometimes the temperature and superexpansibility are further included and the same limit of variation used on the combined factor. On certain small meters the factor is changed only when the orifice plate is changed.

The Reynolds Factor is handled as a multiplier under conditions similar to those above, except in one company which uses the method of addition of 24S values. This company expects to change to the use of a multiplier on certain meters where the variation is not large.

Temperature Factors are changed for various time and temperature intervals from one day and one degree, on up. In general, where accurate recording thermometers are used, the factors are consistent in accuracy with other data used in calculating the flow. The chief source of error is in the large number of meters which use estimated temperatures based on conditions at some other point, and in older thermometers which tend to record temperatures of the pipe shell and the air, rather than of the gas.

Superexpansibility Factors are in almost all cases rigorously applied and probably introduce very little error. On low or steady pressures, changes in the factor may be very infrequent, while on high pressures and large volumes the factor is sometimes applied hourly.

The subject of *Line vs. Flange Connections* has been given considerable study. When the new procedure was adopted, practically all gas company meters were line connected. The tendency now is to discard all old meter tubes and equipment that do not fall within recommended tolerances, and to install flange connections on all new tubes and fittings. One company has been a notable exception, and chose to install line connections on several new 20-inch tubes. The choice was influenced by the greater capacity and the desire to retain uniformity with present equipment.

As for the increase in time required by the new procedure, in orifice metering, there is general agreement on a range of 5 to 10 per cent. Part of the increase is the result of more attention to the care and calibration of old equipment. It is generally agreed that 5 per cent is a reasonable expenditure for the gain in accuracy, and that any future short cuts or improvements cannot be expected to cut the time much below this figure.

Figures on actual increase in accuracy since adoption of the new procedure are still somewhat indefinite. Improvements are most noticeable on lines where gas is metered in at high pressure and out at low pressure. There is undoubtedly a decrease in the average error per meter, some estimates placing the figure at 1 per cent of the metered amount. The tendency for gains and losses to compensate under old methods has meant that in a good many companies the net unaccounted-for has not shown any significant change.

The overall accuracy of orifice metering depends upon all the various mechanical and mathematical operations. An error at any one point will appear in the final result. Opinions as to present sources of largest errors are fairly consistent and result in the following classification:

1. Inaccurate or dirty meter tubes and orifices are adjudged to be the cause of greatest error.

2. Calibration of the gauges is considered to be next in importance as a source of error.

3. Third in magnitude are errors in coefficient data such as temperatures, specific gravities, average pressures, and in the standard coefficients.

4. Errors in reading of the charts are placed next in order.

5. The mathematical operations in calculation of the coefficients and final quantities are considered to be most accurate of the various steps.

The committee recognizes that more intensive investigation might change the classification somewhat, but the changes should not be very great. As already indicated the main purpose of this survey was to point the direction for any further improvements in measurement. These results may be rather surprising to those of us who have been inclined to overemphasize certain features of the new procedure.

*Committee Report: E. H. Fisher, Chairman, Coast Ind. Gas Co.; Hardwick Barnes, San Diego Cons. G. & E. Co.; M. J. Cereghino, L. A. G. & E. Corp.; F. A. Hough, So. Counties Gas Co.; J. E. Spelce, Calif. R. R. Comm.; B. G. Williams, So. Calif. Gas Co.

†Bulletin No. TS-353, C.N.G.A., P.C.G.A., S.C.M.A., Joint Committee Report, Published by the California Natural Gasoline Association, 510 W. 6th St., Los Angeles.

Application of the Reynolds and Expansion Factors in Gas Measurement

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GENERAL adoption of the new A.G.A. procedure in orifice meter work has introduced several new problems. The most radical changes over past methods occur in the use of the Reynolds or viscosity factor and the expansion factor.

These factors complicate the procedure because they vary with the rate of flow and, theoretically, cannot be included in the meter coefficient for all rates of flow, as can the temperature and specific gravity factors.

In the ordinary range of orifice metering, the Reynolds factor is usually smaller than the expansion factor. Furthermore, the Reynolds factor varies inversely as the *square root* of the differential and pressure; while the expansion factor is proportional to the *actual* differential and inversely to the *actual* pressure and therefore varies much more rapidly. High values of the expansion factor occur at high rates of flow, while the reverse is true for the Reynolds factor. This means that the effect of the expansion factor, in terms of final quantities of gas, tends to be even greater than a direct comparison with the Reynolds factor would indicate. For given limits of error we can, then, use a constant Reynolds factor for a much larger range of metering conditions. In cases where the factor does become large and varies considerably, we are given the method of adding a constant quantity to the meter chart extensions. This procedure is theoretically exact for any range of flow and pressure.

The expansion factor may be handled by no less than four different methods. The choice depends mainly on the amount that the factor varies.

For large variations of flow or pressure, the so-called "pressure divider", or "intermediate pressure device" should be given first

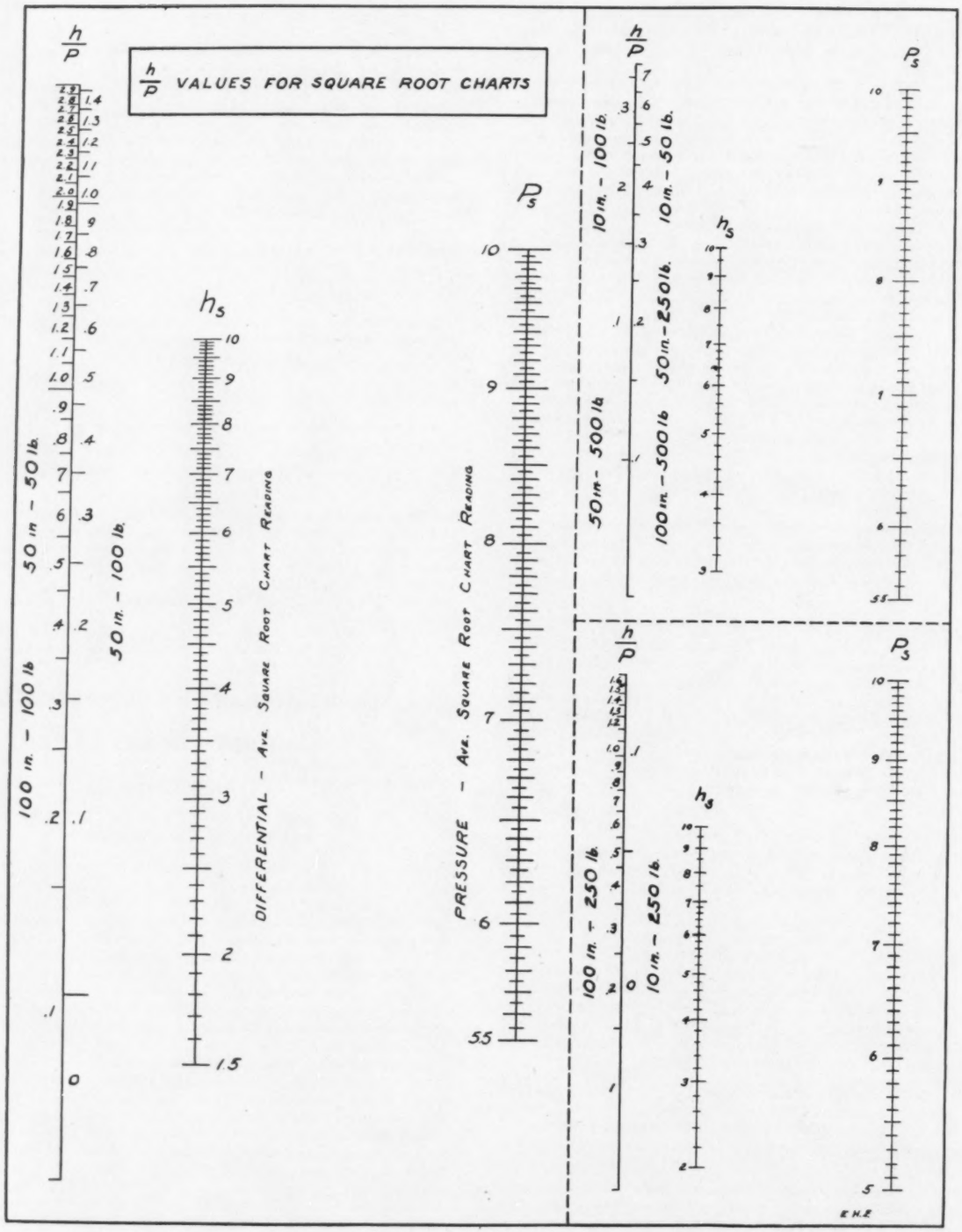
h/P VALUES FOR SQUARE ROOT CHARTS
h/P
100 in. - 100 lb.
50 in. - 50 lb.
50 in. - 100 lb.
h_s
DIFFERENTIAL - Avg. Square Root Chart Reading
P_s
PRESSURE - Avg. Square Root Chart Reading
50 in. - 500 lb.
100 in. - 500 lb.
50 in. - 250 lb.
100 in. - 250 lb.
10 in. - 100 lb.
10 in. - 50 lb.
10 in. - 250 lb.
E.H.E.

CHART NO. 1. Alignment charts for converting square root chart readings to h/P, or absolute pressure ratios.

consideration. Briefly, the device consists of a means for recording a value of static pressure between the upstream and downstream, such that the expansion factor is always equal to 1.000. The description and characteristics of several such devices have been presented by G. B. Reece* and the mathematical analysis and tables for adjustment of the device may be found in Bulletin TS-353.†

The arrangement of the device is shown in Fig. 1. Calibration and routine testing can be accomplished very simply by including an extra value as shown at A. In normal operation this valve remains closed. For testing, valve A is opened and valve B closed. The differential gauge then shows the pressure between the intermediate and the downstream connections. A comparison of this reading with the full differential as shown on the other gauge gives the desired check. A leak in the piping to the pressure recording element would also be indicated by a discrepancy in this check reading.

Certain precautions must be observed in the use of the pressure divider. Mr. Reece has indicated the amount of gas by-passed by the device. This is negligible in most cases. The pressure divider must not be located too far from the taps, or the flow through the piping will affect the differential gauge reading. If the gas is nearly saturated with water vapor, the danger of clogging or freezing as a result of condensate must be considered. This will in some cases, limit the use of the device, but it is about the only source of trouble that cannot be easily overcome.

On installations where the pressure is fairly steady, there is a second mechanical means that may be used for eliminating the expansion factor from chart calculations. An inspection of the tables shows that for all practical purposes, the expansion factor increases in direct proportion to the ratio h/P. If we have a constant pressure, the factor becomes directly proportional to the differential, h. Using this relation we can calibrate the differential gauge to include the expansion factor. For example, if the expansion factor should be 1.0100 at the maximum differential, the gauge can be calibrated 1% above the actual differential at this point. At half the maximum differential, the gauge would read .5% high, equivalent to an expansion factor of 1.0050, and at zero differential the gauge would read zero. The use of this or the intermediate pressure method is not practical where changes in orifice size are frequent, for such changes necessitate recalibration of the gauge or pressure divider.

The third method of adjusting for the expansion factor, consists of the application of mathematical factors based on some average flow condition. This may be called the standard method and it is used in the great majority of cases. It so happens that most of the measurement, particularly by gas companies, occurs at pressures high enough so that the expansion factor is relatively small. In such cases the use of an average factor is accurate within the limits of error of other elements in the measurement system. The factor may be based on average conditions for an hour, day, week or any other period, depending on the amount of variation and the importance of the meter. The lack of uniformity of practice between different companies, and even between different meters in the same company is a source of confusion that is one of the main objections to the method.

If square root charts are in use, the calculation of an expansion factor necessitates the division of the average differential reading, (h_a) by the average pressure reading, (P_a). This ratio of h_a/P_a must then be transformed into absolute units, h/P, that can be used in looking up the value for the expansion factor. By the use of alignment Chart No. 1, values of h/P for use on various pressure and differential ranges are indicated. The use of this chart has been found to speed up the calculations considerably.

The fourth method, if it can be called such, is to neglect the expansion factor entirely. This may occur as a special case of the standard method when the factor is actually 1.0000 or very close to it. In addition there are a good many meters which handle a small or unimportant quantity of gas. If the daily M c.f. measured amounts to only two or three figures, it is sometimes argued that there is no need to worry about a factor involving only the fourth or fifth significant figures. It must be remembered however, that the neglect of the factor introduces an accumulating error. It appears much better to introduce some average factor, even though it is changed only when the orifice size is changed. Any variations from the average will then tend to balance out over a period of time.

Considerable work has been done in combining the Reynolds and expansion factors. The trends of the two factors for any changes in flow are in opposite directions. This means that the combined factor will vary only as rapidly as the difference in the rates of the two individual factors. In the case of line connected meters, with a downstream pressure connection, there is a part of the range of normal operating values in which the two factors will actually cancel each other.

When these factors were first adopted in our measurement, there was some hope that a standard method of handling them would be developed which would be the best for all conditions. The tendency up to the present time has been in the opposite direction, and each company has its own methods and variations. This condition is a healthy one, for out of all this development of ideas, better methods will undoubtedly prove themselves and be generally adopted.

*P.C.G.A. Spring Technical Conference, and Western Gas, April 1936, P. 43.
†"Tentative Standard Procedure for the Measurement of Natural Gas with Orifice Meters" published by California Natural Gasoline Association, 510 West 6th St., Los Angeles.

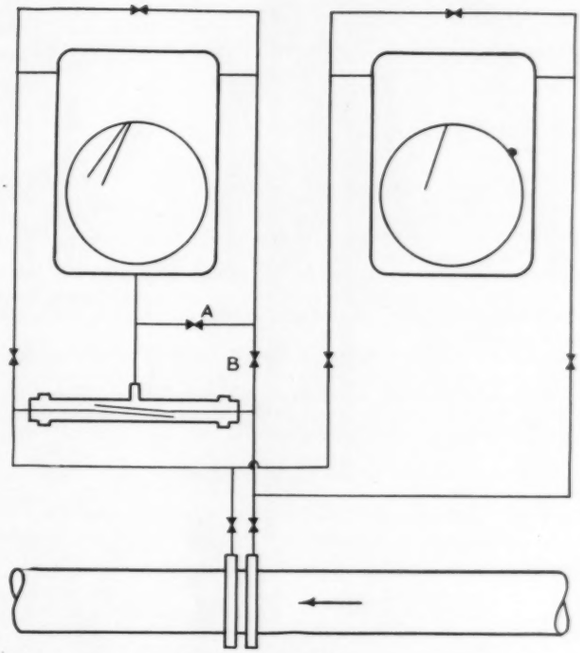

FIG. 1. Piping arrangement for operating and testing the intermediate pressure device.

Effects of Air Density on Measurement of Specific Gravity of Gas

By R. P. WORK
Coast Industrial Gas Company

THE measurement of specific gravity involves the comparison of gas to air not only by definition but in most cases by actual comparison of gas and air in the instrument measuring the specific gravity. Orifice metering procedure has lately involved the use of four significant figures in the determination of orifice meter coefficients. To be consistent with this procedure the specific gravity of natural gas should be determined to the third significant figure. The following analysis shows that density variations of air due to changes in barometric pressure and humidity are sufficient to cause large variations in the third figure of the specific gravity reading.

As far as orifice metering is concerned, the specific gravity of gas may be defined as the ratio of the weight of gas to the weight of an equal volume of dry air, free from carbon dioxide, at the same pressure and temperature.

In this discussion density is defined as the weight of the gas or air per unit volume. Pure air will be understood to mean dry air free from carbon dioxide and other impurities.

From these definitions, specific gravity may be again defined in terms of density. In these terms the specific gravity of gas is the ratio of the density of gas and the density of pure air at the same pressure and temperature.

Expressing this relation in a mathematical form we have:

$$S_g = \frac{D_g}{D_a} \qquad (1)$$

when $T_g = T_a$ and $P_g = P_a$

Where:
S_g = Specific gravity of gas
D_g = Density of gas
D_a = Density of air
T_g = Absolute temperature of gas
T_a = Absolute temperature of air
P_g = Absolute pressure of gas
P_a = Absolute pressure of air

In specific gravity measurement the important factors that determine the density of air are temperature, pressure, and water vapor. Other factors influencing the density of the air may be eliminated in most cases.

The density of air is affected by temperature and pressure in accordance with Charles' and Boyle's laws. If the temperature and pressure of the gas are not the same as the air, the density of the gas may be converted to density under the same conditions as the air by the use of these laws.

$$D_g \text{ (at air temp. and pres.)} = D_g \times \frac{P_a}{P_g} \times \frac{T_g}{T_a} \qquad (2)$$

From the equations (1) and (2) the equation for the specific gravity of gas may be obtained that will serve for gas temperatures and pressures that differ from the air temperature and pressure.

$$S_g = \frac{D_g}{D_a} \times \frac{P_a}{P_g} \times \frac{T_g}{T_a} \qquad (3)$$

The specific gravity of mixtures of water vapor and air is principally a function of the pounds of water vapor per pound of dry air or of absolute humidity. The specific gravity of water vapor is about .6 under atmospheric conditions. It is very fortunate that the specific gravity of water vapor and air varies with the absolute humidity rather than relative humidity because temperature change during the day has little effect on the absolute humidity. The importance of the consideration of the water vapor content of the air may be illustrated by a few examples of the specific gravity of atmospheric air. The specific gravity of saturated air at 50° is .995, and at 50 per cent saturation (relative humidity 50 per cent) the specific gravity is .998. Saturated air at 80 degrees has a specific gravity of .987, and at 50 per cent saturation the specific gravity is .994. To include the water vapor effect in the specific gravity of gas equation it is first necessary to set up the equation for the specific gravity of water vapor and air mixtures.

$$S \text{ (water vapor + air)} = \frac{D_{w+a}}{D_a} \qquad (4)$$

This is true where $T_{w+a} = T_a$ and $P_{w+a} = P_a$.

The subscript (w+a) refers to water vapor and air mixtures.

By transforming this equation and substituting in the equation for the specific gravity of gas, the general equation for the specific gravity of gas is obtained.

$$D_a = \frac{D_{w+a}}{S_{w+a}} \qquad (4)$$

$$S_g = \frac{D_g}{D_a} \times \frac{P_a}{P_g} \times \frac{T_g}{T_a} \qquad (3)$$

$$S_g = \frac{D_g}{D_{w+a}} \times S_{w+a} \times \frac{P_{w+a}}{P_g} \times \frac{T_g}{T_{w+a}} \qquad (5)$$

This general equation will aid in the determination of the humidity, temperature and pressure effects on several of the instruments that compare the density of gas with the density of atmospheric air.

A description of the more common instruments used in the specific gravity measurement of the gas industry is given by O. L. Kowalke in the Gas Age-Record for February 1, 1936.

The determination of the effect of the density of air on the fundamental principles of operation of the various instruments in use is the purpose of this discussion; and mechanics of the instrument will be discussed only when it is necessary to clarify the discussion of the fundamental principle. The accuracy to which temperatures and pressures are controlled is usually dependent upon the mechanical construction of the instruments, and that will be left for the reader to study.

Specific Gravity Measurement Based on Centrifugal Force

The pressure rise between the hub and the tip of a centrifugal fan is directly proportional to the density of the fluid and to the square of the velocity change between the hub and the tip. Expressed in terms of velocity head and then converting to pressure and density we have:

$$h = \frac{V^2}{2G} = \frac{p}{D}$$

Where:
G is the gravitational constant
p is the pressure differential
h is the velocity head.

If the speed of the fan is held constant, the velocity term becomes constant and the pressure differential is then known to be directly proportional to the density of the gas. Because air is often used to calibrate this instrument the general equation for the specific gravity of gas is useful.

$$D = K \times p$$

$$\frac{D_g}{D_{w+a}} = \frac{p_g}{p_{w+a}}$$

$$S_g = \frac{p_g}{p_{w+a}} \times S_{w+a} \times \frac{P_{w+a}}{P_g} \times \frac{T_g}{T_{w+a}}$$

Specific Gravity Measurement Based on Viscosity

The motion of any fluid is resisted by an internal drag called viscosity. Instruments measuring the specific gravity of gas by measuring the relative frictional resistance of surfaces moving in gas and air are actually measuring the relative viscosity of gas and air.

The theory upon which this type of instrument is based is derived from Reynolds criterion. It has been found that under turbulent conditions of flow, the ratio of the frictional resistance to the velocity squared times the density of the fluid is practically a constant.

$$\frac{R}{V^2 D} = K \quad (R = \text{resistance})$$

If the velocity is held constant for both the air and the gas, the ratio of the frictional resistance of the gas to the frictional resistance of the air will be equal to the ratio of the densities of the gas and the air.

$$\frac{R_g}{R_{w+a}} = \frac{D_g}{D_{w+a}}$$

The general equation for the specific gravity of gas may again be used to determine the effect of temperature, pressure, and humidity on the densities, and thus the specific gravity of the gas.

Measurement Based on the Principle of Archimedes

If a closed vessel is surrounded by a gas, the vessel is buoyed up by a force equal to the weight of the volume of gas displaced. The use of this principle of Archimedes takes various forms in the instruments measuring specific gravity but it is used directly in the Edwards gas density balance and other instruments of the same type. This type of instrument balances a relatively large closed vessel against dense weights on a beam balance. The balance is arranged so that it may be surrounded by either gas or air. As the density of the gas increases, the closed vessel will be buoyed up with greater force thus changing the position of the beam. The amount of deflection of the beam is therefore directly related to the density of the gas and it may be calibrated to read in terms of density or buoyant force of the closed vessel. With this arrangement the general equation can again be used.

$$S_g = \frac{F_g}{F_{w+a}} \times S_{w+a} \times \frac{P_{w+a}}{P_g} \times \frac{T_g}{T_{w+a}}$$

Where:
F_g = buoyant force of the gas.
F_{w+a} = buoyant force of the air.

If the scale, that measures the deflection, is calibrated directly in specific gravity the correction may be handled in the same manner as is later described in the discussion of the column type instrument.

This instrument is also used in another way. If the beam is balanced with air at atmospheric pressure and then again balanced

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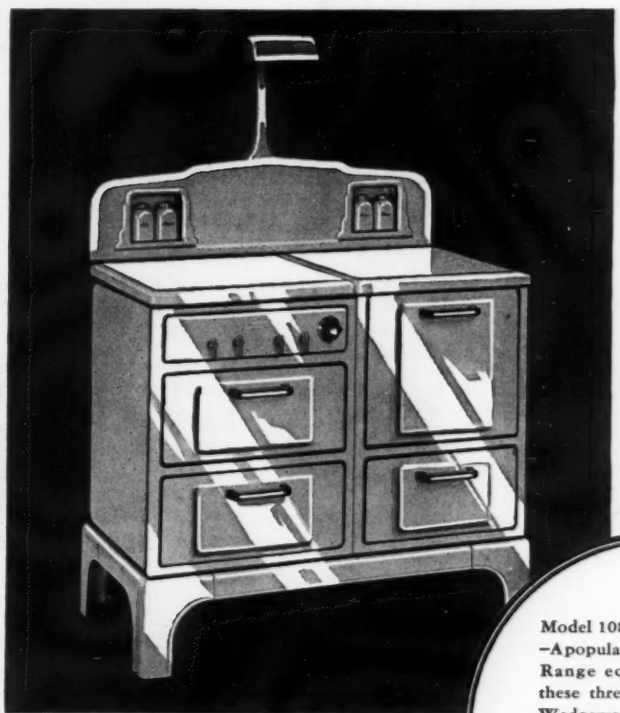

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with gas by increasing the pressure of the gas so that the buoyant forces are the same, the ratio of the densities at atmospheric pressure will be inversely proportional to the ratio of the pressures. In effect all that has been done in this method is to make the density of the gas and air the same by raising or lowering the pressures. If the general equation is again referred to, it will be seen that it still applies in this case. Since the density of the air and the gas are the same their ratio drops out and we have:

$$S_g = S_{w+a} \times \frac{T_g}{T_{w+a}} \times \frac{P_{w+a}}{P_g}$$

All of these instruments to which the general equation applies are similarly affected by errors in determination of the specific gravity, temperature and pressure of the air used as a basis of comparison. To give certainty to the third figure of the gas specific gravity, the temperature must be measured or the temperature agreement of the gas and air must be within 1 degree. Pressure measurements or pressure agreement must be within one-twentieth of an inch of mercury. Neglect of the humidity effect of the air will cause an error of four in the third figure at 80 degrees at 50 per cent relative humidity.

Measurement Based Upon the Weight of a Column of Gas

Pressure difference measured at the bottom of columns of air at different densities is well known to those who are familiar with stacks and vents. Instruments measuring specific gravity by the use of this method may differ widely in their method of measuring the pressure difference but they are all subject to the same gas laws. The pressure at the bottom of a column of gas will depend upon the pressure at the top of the column and the height and density, or weight, of the gas in the column. The pressure difference between a column of air and a column of gas of equal height is then equal to the height of the column times the difference in the densities.

For the purpose of this discussion calculations can be considerably simplified by assuming that the temperature of the gas and the air are the same. In this type of instrument any variation from the standard, or calibration, pressure and temperature will affect the reaction of the instrument. If the densities of the gas and air are both increased 1 per cent, as they might be by a temperature and pressure change, the pressure differential between the column will increase 1 per cent even though the ratio of the density of the gas and air remain the same.

In case the specific gravity is calculated at each measurement of the pressure difference it is convenient to base all calculations on a standard temperature and pressure, and pure air.

Under standard conditions we have:

$$\frac{p}{H} = (D_{as} - D_{gs}) \qquad (6)$$

Where (H) is the height of the column and (p) is the pressure differential. The subscript (s) refers to standard conditions.

Using water vapor and air mixtures instead of pure air and at any pressure and temperature the equation becomes:

$$\frac{p}{H} = (D_{as} \times S_{w+a} - D_{gs}) \times \frac{P}{P_s} \times \frac{T_s}{T}$$

By dividing both sides by D_{as} and bringing the standard pressure and temperature terms to the left hand side, the equation is considerably simplified:

$$\frac{p}{H} \times \frac{1}{D_{as}} \times \frac{P_s}{T_s} = (S_{w+a} - S_g) \frac{P}{T}$$

The column height, the density of air at standard conditions, the standard pressure and standard temperature may be lumped into one constant C. This enables the equation to be transformed to its final and useful form.

$$S_g = S_{w+a} - C \times p \times \frac{T}{P}$$

The column type instrument makes a good recording specific gravity instrument. Due to the fact that the reading of the instrument must decrease as the pressure differential increases, the chart or scale must be calibrated in terms of one minus the pressure differential times a constant C_1 that includes the height of the columns.

$$\text{Reading} = 1 - C_1 \times p$$

At standard conditions the reading is equal to the specific gravity of the gas. Using equation (6) we have:

$$\text{Reading}_s = S_g = \frac{D_{gs}}{D_{as}} = 1 - C_1 (D_{as} - D_{gs}) \qquad (7)$$

Under any condition of temperature and pressure we have:

$$\text{Reading}_1 = 1 - C_1 (D_{as} - D_{gs}) \times \frac{P_1}{P_s} \times \frac{T_s}{T_1}$$

The temperature and pressure correction, that must be added to the reading to give the correct specific gravity, will be Reading $_s$ minus Reading $_1$.

Temperature and Pressure Correction =

$$C_1 (D_{as} - D_{gs}) \left(\frac{P_1}{P_s} \times \frac{T_s}{T_1} - 1\right)$$

But from (7)

$$C_1 = \frac{1 - S_g}{D_{as} - D_{gs}}$$

giving us the final equation for the temperature and pressure correction, that must be added or subtracted from the Reading according to the sign of the correction:

$$\text{Temperature and pressure correction} = (1 - S_g) \left(\frac{P_1}{P_s} \times \frac{T_s}{T_1} - 1\right)$$

The temperature may be automatically compensated in the instrument so that this term will drop out of the equation. Barometric pressure changes are not very rapid and use of average barometric pressure during a day will cause little error.

If air and water vapor mixtures are used, the humidity correction may be derived in the same way.

$$\text{Reading}_2 = 1 - C_1 (D_{as} \times S_{w+a} - D_{gs})$$

$$\text{Reading}_s - \text{Reading}_2 = C_1 (D_{as} \times S_{w+a} - D_{gs}) - C_1 (D_{as} - D_{gs})$$

$$= C_1 D_{as} (S_{w+a} - 1)$$

But from equation (7) we have:

$$C_1 = \frac{1 - \frac{D_{gs}}{D_{as}}}{D_{as} - D_{gs}} = \frac{1}{D_{as}}$$

By substituting this value for C_1 in the former equation we have the final form of the humidity correction, for the recording type of the column specific gravity measuring instrument that is added to the reading of the instrument.

$$\text{Humidity correction} = S_{w+s} - 1$$

Due to the fact that the humidity correction is applied to the gas reading, it has a relatively greater effect on the gas than on the air. If the air has a specific gravity of .996, as it has at 60 degrees and 50 per cent relative humidity, a gas specific gravity reading of .670 is changed to .666 which is a .6 per cent change while the humidity effect on the specific gravity of the air was only .4 per cent.

Handling the humidity and pressure correction separately involves a slight error that may be neglected. This instrument may be set to read the true specific gravity at average conditions without corrections. Over a long period of time the average specific gravity might be correct, but for calibration purposes and for the determination of the variations in the specific gravity these corrections must be taken into account.

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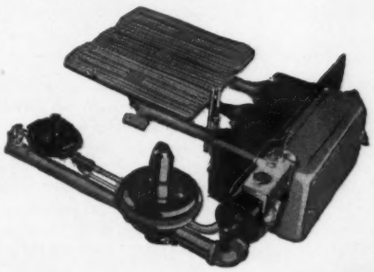

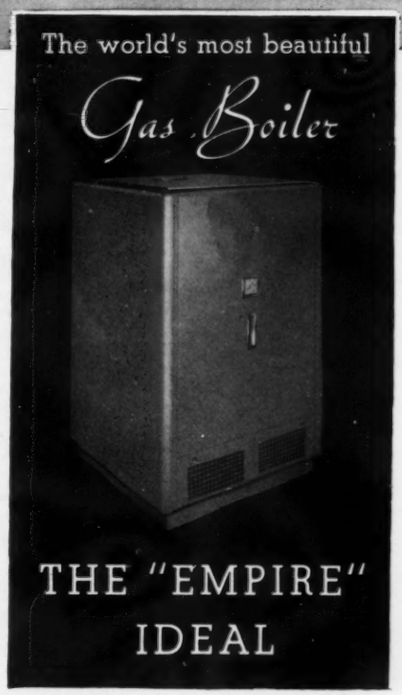

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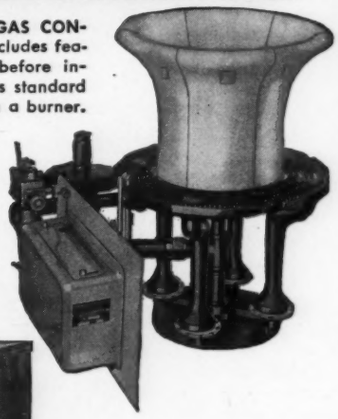

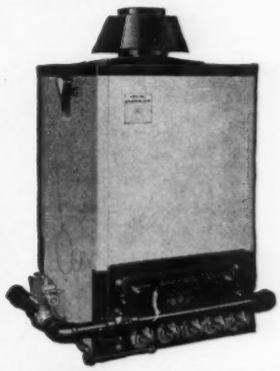

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Gas Calorimetry*

THIS Subcommittee was formed to investigate the general subject of gas calorimetry, with particular reference to "gross" heating value determinations on natural gas and other gases of high calorific value.

The only generally recognized and accepted test procedures and correction tables available at present for gas calorimetry are those developed in 1914 by the United States Bureau of Standards, gases of 600 and 1000 B.t.u. being specifically dealt with; these data do not apply to gases above 1000 B.t.u., nor do they necessarily apply to some of our present day mixed or air-diluted gases of less than 1000 B.t.u. It was therefore felt that the whole procedure of gas calorimetry should be reexamined.

This report consists of the following:

1. Discussion of design, maintenance and operation of conventional apparatus and instruments.

2. Discussion of correction factors, with particular reference to the "humidity" correction.

3. Discussion of prehumidification of combustion air, and design of apparatus.

4. Bibliography.

5. Paper by W. A. McGlashen entitled "Effect of Atmospheric Humidity in Gas Calorimetry," presenting:

(a) Correlation and comparison of humidity correction tables from various sources.

(b) Development of equation for computing humidity corrections for any conditions of temperature, relative humidity and gas calorific value.

(c) Combustion air relative humidities at which the humidity correction becomes zero.

(d) Humidity correction tables for gases of 850, 950, 1050, 1100, 1150 and 1200 B.t.u.

Apparatus and Instruments

It is agreed that the apparatus and instruments, and procedures for maintenance and operation thereof, are satisfactorily developed and described in the Bureau of Standards Technical Paper No. 36 and Circular No. 48, except in the following details:

(1) The 1/10 cubic foot bottle used for calibrating the wet test meter is so small as to create the possibility of serious errors in calibration, due to unequal temperatures, misalignment of meniscus with marker, back pressure of meter, etc. A larger bottle is suggested.

(2) As already discussed, humidity correction tables are not available for gases above 1000 B.t.u.

(3) The non-provision of a humidity control device for combustion air makes necessary the humidity correction, which, at the best, and even if available, is laborious and a potential source of error. This will be detailed later.

The following points of procedure, although dealt with in the Bureau of Standards publications, have been indicated by the Subcommittee membership as meriting brief discussion:

(1) Thermometers. Inlet and outlet thermometers, as a pair to be used together, should be checked against the same standard thermometer, as two "standards" may not necessarily agree. They should be checked in their protective armor, if any, and at the point of immersion which will exist when they are inserted in the calorimeter, so as to develop the influence of the protective armor.

(2) Meter Prover. Care should be taken, by presaturation if necessary, that the air or gas in the meter prover be saturated with water vapor, and at the temperature of the meter, before it is discharged through the meter.

(3) Meter. Care should be taken that the gas for test be saturated before it enters the meter.

Correction Factors: "Humidity" Correction

It is agreed that the correction factors as developed in the Bureau of Standards publications are satisfactory, with the exception of the "humidity" correction, which latter is cumbersome and potentially inaccurate. This humidity correction is necessary when the combustion air is at a lower or higher relative humidity than approximately 85 per cent, because of heat being carried out of the calorimeter by the water-vapor-saturated products of combustion. The correction can be theoretically developed when certain operating controls are assumed, the most important of which is the maintenance of a definite per cent of excess air in the flue products; in practice 40 per cent excess air is chosen. This percentage of excess air can be roughly approximated by decreasing the gas input to 70 per cent of that at which carbon monoxide is formed. It can be exactly determined by analyzing the flue products and interpreting them in connection with an analysis of the gas under test. The humidity correction can be avoided if the "net" heating value is determined, and the "gross" heating value calculated from a knowledge of the hydrogen percentage in the gas which, in turn, calls for an analysis of the gas.

A strictly correct determination, therefore, calls for very careful and time-consuming adjustment of apparatus, a considerable quantity of sample, and knowledge of the chemical analysis of the sample to an accuracy such that a heating value could be calculated with fair accuracy without going through the calorimetric performance. A small unknown sample could theoretically not be tested for heating value with a calorimeter alone. The only usefulness of calorimetric equipment, without auxiliary gas analysis apparatus, is for routine testing of gases, the approximate composition and heating value of which are known. It is granted, of course, that in most cases the approximate composition and heating value of a gas are known, and humidity corrections for the common mixed and natural gases are presented in the paper by W. A. McGlashen. It must be remembered, however, that these corrections are based on 40 per cent excess air in the flue products, involving careful adjustment and maintenance if serious error is to be avoided.

Prehumidification of Combustion Air.

It would seem as if prehumidification of combustion air would eliminate all the above difficulties, and convert the calorimeter into a fundamental instrument. With control of air humidity, the calorimeter could be operated at any gas rate and air-gas ratio so long as incomplete combustion did not result (observable by odor in flue products), or flue products did not rise appreciably above inlet air temperature, and so long as the conventional difference was maintained between inlet and outlet water temperature. There would be no correction for combustion air humidity. As shown in Mr. McGlashen's paper, the air relative humidity per cent to give zero correction varies from 76 for 250 B.t.u. gas to 90 for 2500 B.t.u. gas. It would therefore be necessary only to run one sample of gas with combustion air at approximately 85 per cent relative humidity, to ascertain the approximate B.t.u., and then another sample with the air at the correct relative humidity. For reasonably accurate work with the ordinary mixed or natural gases it would merely be necessary to humidify the air to a percentage slightly under saturation.

Apparatus for Prehumidification of Combustion Air

A satisfactory apparatus for the prehumidification of combustion air should be capable of near-saturation, and preferably of saturation control, of any amount of air up to the maximum required by a flow calorimeter (approximately 50 cubic feet per hour); at any of these rates, resistance to flow of air should not be set up; air temperature should not be appreciably changed; dimensions should be reasonable to conserve bench space; attachment should be possible to any existing design of calorimeter; gas burner performance should be capable of observation during combustion and adjustment in the humidified air.

The following methods of humidification were considered:

1. Passage of air over a still water surface. Working apparatus was built, and found unsatisfactory because of lack of control for varying quantities of air at varying initial relative humidities; also because saturation was inadequate when using large volumes of air at low initial humidity.

2. Passage of air through wicks wetted by water and variable in size or number. Working apparatus was built, and found unsatisfactory for the same reasons as listed in (1) above.

3. Bubbling of air through water. Considered unsatisfactory because of requiring air under pressure, and because of known difficulty of obtaining saturation with bubbling devices.

4. Treating air with steam. Considered unsatisfactory because of necessity for steam generating device and control thereof, and because of elevation of air temperature during steam treatment.

5. Insertion of nest of glass beads or broken tubing in bottom of calorimeter, under burner, wetted by water of condensation, and through which combustion air must pass. Apparatus secured from instrument manufacturer; found unsatisfactory for large volumes of air because of restriction to flow, and inadequate humidification;

*Committee Report: Guy Corfield, Chairman, L. A. G. & E. Corp.; A. B. Allyne, So. Counties Gas Co.; Hartwick Barnes, San Diego Cons. G. & E. Co.; W. A. McGlashen, L. A. G. & E. Corp.; M. A. Richford, P. G. & E. Co.; S. C. Schwarz, Portland Gas and Coke Co.; J. E. Spelce, California Railroad Commission; B. G. Williams, So. Calif. Gas Co.

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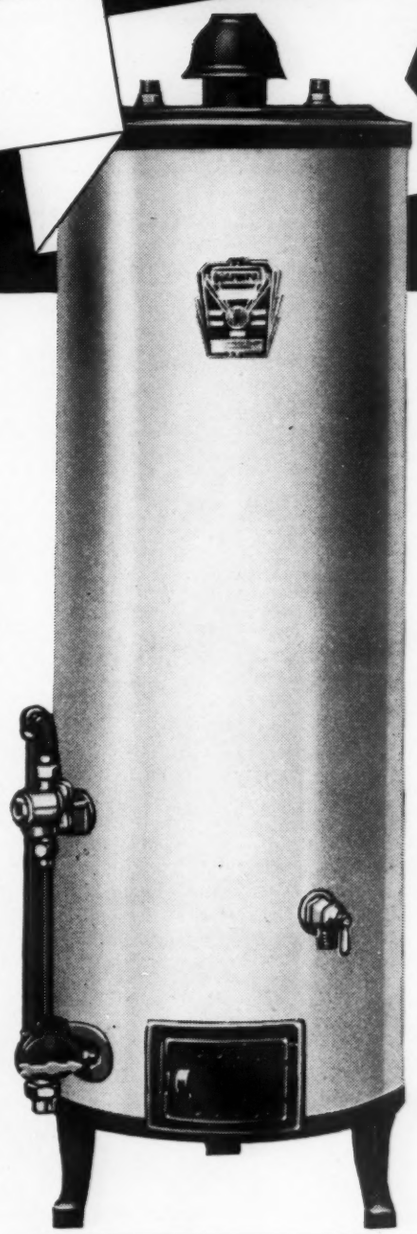

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TABLE NO. 1. RESULTS OF THE OPERATION OF A WATER-FLOW CALORIMETER WITH AND WITHOUT HUMIDITY CONTROL OF COMBUSTION AIR.

Corrections for Humidity Are from McGlashen's Equation (7).

			Combustion Air from Room								
	Temperature		Without Humidity Control				With Humidity Control				
Test No.	Room	Inlet Water	Air Temp.	Rel. Hum.	R.H. Corrn.	Total B.t.u.	Total B.t.u.	R.H. Corrn.	Rel. Hum.	Air Temp.	Damper Setting
1	71	71	71	65	+ 3	1123	1127	− 2	100	68	40% Excess Air
2	71	71	71	65	+ 3	1124	1126	− 2	100	68	40% Excess Air
3	72	69	72	49	+ 6	1155	1152	− 1	90	70	40% Excess Air
4	70	70	69	63	+ 4	1155	1156	− 1	90	70	40% Excess Air
5	75	70	75	51	+ 7	1139	1137	+ 0	86	70	40% Excess Air
6	75	74	75	47	+ 7	1131	1132	+ 1	82	74	40% Excess Air
7	78	78	78	49	+ 8	1100	1104	+ 0	86	76	40% Excess Air
8	78	78	78	49	+ 8	1116	1120	− 1	91	78	40% Excess Air
9	80	76	80	44	+ 9	1127	1130	+ 0	86	77	40% Excess Air
10	80	77	80	41	+11	1137	1137	+ 0	87	79	40% Excess Air
11	81	79	80	38	+10	1132	1136	− 2	96	79	40% Excess Air
12	81	80	81	47	+ 9	1129	1131	− 1	91	80	40% Excess Air
13	81	80	81	47	+ 9	1107	1106	− 1	91	80	40% Excess Air
14	82	78	82	45	+10	1137	1136	+ 0	87	81	40% Excess Air
15	82	80	82	45	+10	1138	1140	− 1	91	81	40% Excess Air
16	79	80	79	44	+ 9	1120	1122	− 2	96	79	40% Excess Air
17	76	77	76	58	+ 5	1135	1137	− 1	91	78	40% Excess Air
18	72	72	72	56	+ 5	1128	1130	+ 0	86	75	40% Excess Air
19	70	71	70	59	+ 4	1125	1123	+ 0	86	72	40% Excess Air
20	70	69	70	55	+ 5	1136	1137	− 1	90	70	40% Excess Air
21	74	72	74	51	+ 6	1124	1123	− 1	96	73	40% Excess Air
22	79	74	79	47	+ 8	1139	1139	+ 0	86	77	40% Excess Air
23	78	76	74	26	+10	1115	1118	− 1	90	71	40% Excess Air
24	78	76	74	26	+10	1118	1120	− 1	90	71	40% Excess Air
25	78	77	76	28	+11	1127	1128	− 1	90	71	40% Excess Air
26	78	77	76	31	+11	1127	1127	− 1	90	72	40% Excess Air
27	75	72	75	40	+ 8	1124	1123	− 1	90	72	40% Excess Air
28	75	72	75	40	+ 8	1115	1124	− 1	90	72	Wide Open
29	81	75	80	41	+11	1149	1149	+ 0	87	78	40% Excess Air
30	81	75	80	41	+11	1142	1151	+ 0	87	78	Wide Open

also unsatisfactory in general because burner flame cannot be observed with device in place.

6. Passage of air through water spray. A device was constructed, consisting essentially of an enclosed helical coil of copper tubing drilled with small holes so as to discharge a spray of water inward, through which spray the air could be drawn; also an air by-pass valve so that external non-humidified air could be introduced as desired; also a wet and dry bulb psychrometer. This device was operated with tap water, requiring a maximum of 28 gallons of water per hour at 1 pound gauge pressure, and it was found possbile to obtain practically complete humidification of 60 cubic feet of air per hour, with this air entering at a relative humidity of 17 per cent at 75°F. Attachment was made to the calorimeter through what is essentially an enclosure of the base of the calorimeter, in which enclosure the burner can be manipulated and observed through a door and window.

With this combination of apparatus, even though somewhat crude in construction, it was found possible to obtain almost complete control of the combustion air humidity. The calorimeter was operated accordingly, with results as shown in Table No. 1.

Each of the tests numbered 1 to 26 inclusive represents two determinations, one immediately following the other, on the same gas, one with and one without humidity control. The humidity corrections of 1 and 2 B.t.u. in the "with humidity control" column were necessary because the control was not exactly the 86 per cent required. It will be noted that the B.t.u. figures obtained are practically the same, regardless of whether humidity corrections or humidity control were used, thus establishing the validity of the humidity control method. Unfortunately the lowest air relative humidity was 26 per cent (Tests 23 and 24) calling for a humidity correction of only 10 B.t.u., but there is every reason to believe that lower relative humidities would have been equally well handled by the humidity control method.

Tests numbered 27 to 30 inclusive show that the humidity control method removes the necessity for damper control to 40 per cent excess air in the flue products. Test 27 shows a gas of 1123-1124 B.t.u. by either method while Test 28 on the same gas shows a lowering of 9 B.t.u. when the damper was opened wide, without humidity control, and no effect with humidity control. Similarly, Tests 29 and 30 show a lowering of 8 B.t.u. under similar variations in operation.

These tests are considered justification of the efficacy of prehumidification of combustion air, in general, and of the water spray system, in particular, for humidity control, and from experiences with the crude apparatus already constructed, the instrument design shown in Fig. 1 is submitted as a workable device for this purpose. It will be observed that this assembly consists of a water spray humidifying chamber (at the left), a wet and dry bulb psychrometer and connecting duct (in the center) and a housing for attachment to the calorimeter (on the right). This housing is at once a support for the calorimeter, and an enclosed space in which the burner can be manipulated through the door (30), and observed through the window (29) while in the humidified atmosphere. This housing also eliminates room drafts that otherwise may pass around and through the base of the calorimeter. The burner (not shown) is inside the housing and attached to a short length of rubber tubing that is, in turn, attached to a nipple (31) permanently inserted in the back wall of the housing; to the other, or outer, end of this nipple is attached the tubing from the wet test meter.

To operate this humidifier with overhead tank or tap water, the source of water is connected at (14), part of it passing through the minimum spray tube (13) and the remainder through control valve (12) and upper connection (5) to the water chamber (6), from which it passes through the orifices in the spray cylinder (10) in jets which tend to converge at the minimum spray tube (13) placed along the center line of the spray cylinder (8).

Some control of the relative humidity may be secured by changing the velocity of the jets of water through the orifices in the spray cylinder (10) by adjusting the inlet water valve (12) and water by-pass valve (16) to allow more or less water to by-pass the orifices in the spray cylinder (10) through upper connection (7) and flow back into the water reservoir (15) through lower connection (19), excess water being drained off through water drain valve (22) and overflow weir (26).

Further control of the humidity may be secured by moving the spray control cylinder (9) up or down in the inlet air passage (1)

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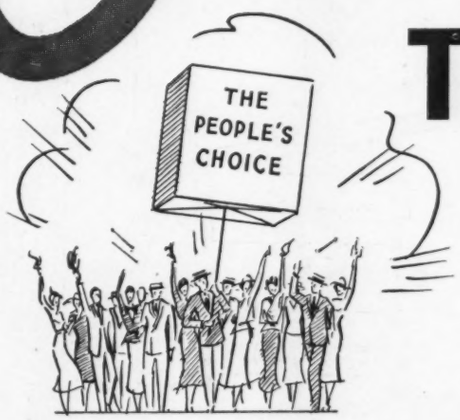

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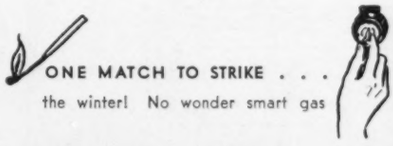

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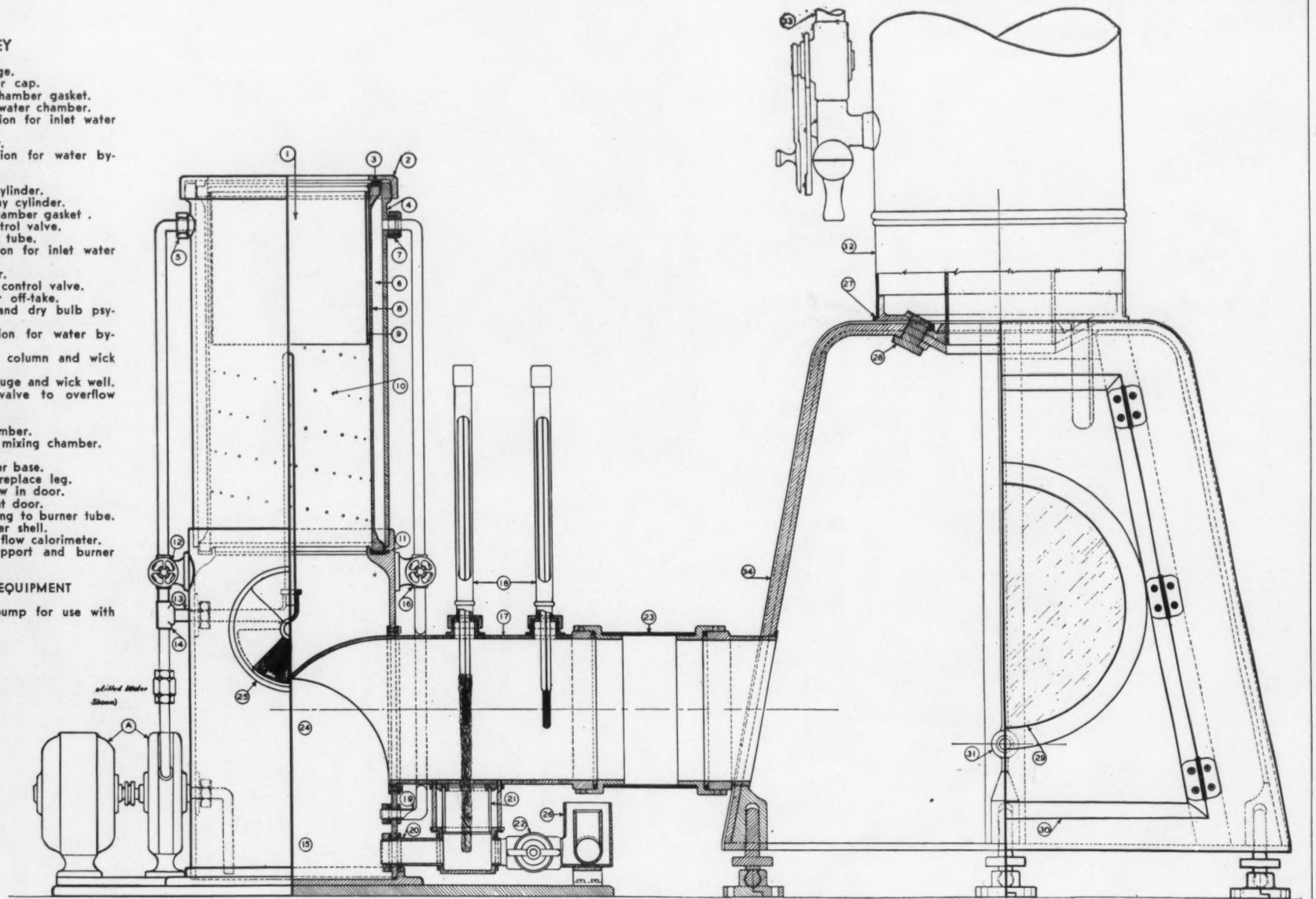
KEY

1. Inlet air passage.
2. Water chamber cap.
3. Upper water chamber gasket.
4. Outer wall of water chamber.
5. Upper connection for inlet water tube.
6. Water chamber.
7. Upper connection for water by-pass tube.
8. Spray cylinder.
9. Spray control cylinder.
10. Orifices in spray cylinder.
11. Lower water chamber gasket .
12. Inlet water control valve.
13. Minimum spray tube.
14. Lower connection for inlet water tube.
15. Water reservoir.
16. Water by-pass control valve.
17. Combustion air off-take.
18. Shielded wet and dry bulb psychrometer.
19. Lower connection for water by-pass tube.
20. Inlet to water column and wick well.
21. Glass water gauge and wick well.
22. Water drain valve to overflow weir.
23. Flexible joint.
24. Air mixing chamber.
25. Air by-pass to mixing chamber.
26. Overflow weir.
27. Flow calorimeter base.
28. Cap screw to replace leg.
29. Circular window in door.
30. Hinged air-tight door.
31. Gas intake fitting to burner tube.
32. Flow calorimeter shell.
33. Water inlet of flow calorimeter.
34. Calorimeter support and burner chamber.

OPTIONAL EQUIPMENT

A—Motor driven pump for use with distilled water.



DESIGN OF PROPOSED INSTRUMENT FOR
HUMIDITY CONTROL OF COMBUSTION AIR FOR
WATER-FLOW CALORIMETERS
RESEARCH LABORATORY
LOS ANGELES GAS AND ELECTRIC CORP.
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to regulate the number of jets of water passing across the inlet air passage.

A more sensitive control of the humidity may be had by the use of the air by-pass (25) to admit more or less untreated air to the air mixing chamber (24).

If operation with motor driven pump and distilled water is desired, the distilled water is circulated from the water reservoir (15) to lower connection (14). In all other respects the operation and control is the same as that with overhead tank or tap water except for the addition of make up water to maintain the water level in the reservoir (15).

The appraisal of the various methods of combustion air prehumidification, construction of water spray apparatus, and design of instrument assembly shown as Fig. 1, was done by W. A. McGlashen in the Research Laboratory of the Los Angeles Gas and Electric Corporation.

Summary and Conclusion

The Gas Calorimetry Subcommittee presents herewith:

1. A discussion of existing calorimetric practice.
2. Humidity correction formulae and tables for common fuel gases of any calorific value.
3. The desirability of prehumidification of combustion air.
4. A design for apparatus to control humidity of combustion air.

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EFFECT OF ATMOSPHERIC HUMIDITY IN GAS CALORIMETRY; THE DEVELOPMENT OF EMPIRICAL EQUATIONS FROM TEST DATA*

THIS paper presents a means of comparison between the results of methods for determining the correction to be applied to the observed heating value obtained by the use of a water flow calorimeter, to obtain the total heating value of a gas. This correction is commonly known as a "humidity" correction. A study of the published reports of the several investigators was made and resulted in separating them into two groups according to the general method used and the magnitude of the resulting corrections. The study then consisted of the development of an empirical equation, for each group, to express the humidity correction in terms of the observed heating value and the temperature and relative humidity of the combustion air, in order that a proper comparison could be made between the results given by the various methods.

During the progress of this work several empirical equations were developed to express the humidity correction under special operating conditions and are important in that they not only call attention to certain differences in the results of the methods but, in at least one case, show an agreement between all methods under certain operating conditions.

A "Z" chart is presented for the solution of each of the two general empirical equations. There is also included an alignment chart which gives a comparison between the equations in the form of a ratio.

The writer desires to record an acknowledgement of his indebtedness to those men whose published data have been used as a basis of this work.

* Submitted by W. A. McGlashen, Los Angeles Gas and Electric Corp.

PART ONE

THE DEVELOPMENT OF EMPIRICAL EQUATIONS FROM TEST DATA OF GROUP ONE

As a result of the use of gas of heating values ranging from 200 to 3200 B.t.u. per cu. ft. and the trend toward the development of a system of sale of gas to industrial gas customers on a price-per-unit-of-energy basis there is a definite need for more information regarding the corrections to be used in industrial gas calorimetry and, as a step in that direction, this paper has been prepared.

This paper consists of the development of an empirical equation to express the humidity corrections to be applied to the observed heating value, obtained with a flow calorimeter, with only such data as are available to the operator during the test. The equation has been developed from data that have been proven by actual experiment and experience.

There are also given the graphs for the rapid solution of the empirical equations as well as humidity corrections in tabular form for certain observed heating values.

In order to clarify the problem, the following definitions are given:

Total Heating Value of a Gas: The total heating value of a gas, expressed in the English system of units, is the number of British thermal units produced by the combustion, at constant pressure, of the amount of gas which would occupy a volume of 1 cubic foot at a temperature of 60° F., if saturated with water vapor, and under a pressure equivalent to that of 30 inches of mercury at 32° F. and under standard gravity, with air of the same temperature and pressure as the gas, when the products of combustion are cooled to the initial temperature of the gas and air and when the water formed by combustion is condensed to the liquid state. (Technologic Paper No. 36, B. of Stds., p. 13.)

Observed Heating Value: The observed heating value for a flow calorimeter will be understood to be the value obtained by multiplying the mass of water which flowed through the calorimeter during the test by the corrected rise in temperature of the water, and dividing by the volume (referred to standard conditions of 60° F .and 30 inches) of gas burned. (Technologic Paper No. 36, B. of Stds., p. 14.)

From the above definitions of "total heating value" and "observed heating value" it follows that when the necessary corrections for loss of heat to the surroundings and that carried off in the products are applied to the "observed heating value" we arrive at the "total heating value" of the gas.

We are concerned here only with those corrections to the "observed heating value" which allow for the latent heat of that part of the water which is formed in combustion and which is carried off as vapor in the products of combustion. These corrections are affected by the volume and humidity of the entering air, their magnitude depending upon the excess (or deficiency) of water carried out over that carried into the calorimeter. These corrections are designated in this discussion as "humidity corrections".

Data Available

The data available consist of the tables published in Technologic Paper No. 36, B. of Stds., for 600 B.t.u. illuminating gas and 1000 B.t.u. natural gas, and those corrections for 210, 300, 550, 1700 and 2000 B.t.u. from the results of experiments by Mr. Francis Fahey, Brooklyn Union Gas Co., which were published in tabular form in the August 12, 1933, issue of "Gas Age-Record".

Procedure

The following notation will be used:

Y = humidity correction in B.t.u.
X = per cent relative humidity of the air.
Y_o = value of "Y" when "X" = 0.
X_o = value of "X" when "Y" = 0.
T = temperature of the air in ° F.
H = observed heating value in B.t.u.

The problem is to determine from the experimental data the humidity correction "Y" in terms of the observed heating value "H", the air temperature "T" and the relative humidity of the air "X".

The values of "Y"corresponding to "X" at "T" for the given values of "H" are plotted on rectangular co-ordinate paper, the points which correspond to the actual test data being designated by small circles. The curves that most nearly approach those values

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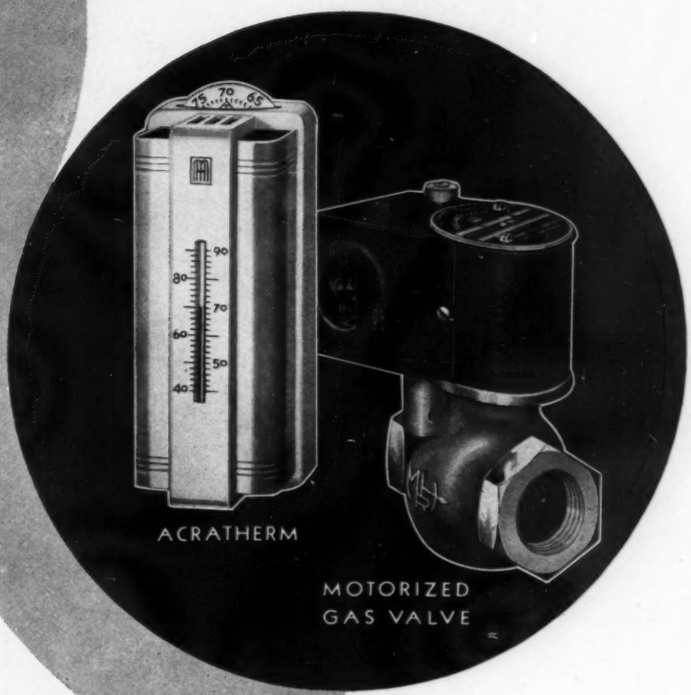

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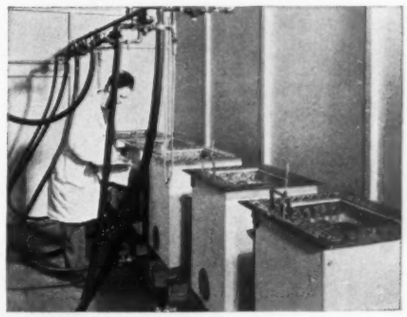

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are drawn as heavy black lines.* This results in a series of empirical curves for each of which an equation is written in the form:

$$Y = mx + Y_o \qquad (1)$$

in which "m" = the slope of the line (Tan ϕ) which, in this particular case, is negative since the angle ϕ is a second quadrant angle.

It is evident from charts numbered 1 to 7 inclusive that:

$$Y_o = f(H),\ f(T) \text{ and } X_o = f(H)$$

in which "f" is a function (as yet undetermined) of the variables shown in the parenthesis.

Now, by substituting the expression $(Y_o \div X_o)$ for "m" in equation (1) we have:

$$Y = -\frac{Y_o}{X_o} X + Y_o \qquad (2)$$

which is identical and includes "Y_o" and "X_o" for which we may derive equations that will express their values in terms of the known quantities.

Chart No. 8

$$Y_o = f(T)$$

When the four values of "Y_o" and the corresponding values of "T" for each of the seven values of "H" (see charts numbered 1 to 7 inclusive) are used to plot the points "T", "Y_o", on semi-logarithmic paper it is found that curves drawn through them are straight lines for each value of "H" and therefore may be expressed by the equation:

$$Y_o = C\,10^{mT}$$

in which: m = the slope of the line divided by "K" or m = Tan $\phi \div K$, where "K" is the scale value of the chart, and C = the value of "Y_o" when "T" = 0.

The values of "K" and ϕ (the angle between the curves and the "T" axis) have been determined from the chart and are as follows:

$$K = 66.5;\ \phi = 46^\circ - 36';\ \text{Tan}\,\phi = 1.0575$$

from which:

$$m = 0.0159$$

which is a constant for all values of "T" and "H" and we may write the equation as:

$$Y_o = C\,10^{0.0159\,T} \qquad (3)$$

from which the average numerical value of "C" has been calculated for each of the seven values of "H" by substituting the numerical values of the points T, Y_o, which were used to plot chart numbered 8, in equation (3) and solving for "C".

It is now evident that "C" varies with "H", that is, "C" is a function (as yet undetermined) of H.

Chart No. 10

$$C = f(H)$$

The average numerical values of "C", from the equations written on the curves of chart numbered 8, and the corresponding values of "H" were used to plot the points "H", "C", on rectangular coordinate paper. The approximate curve of the function is a straight line which passes through the origin the equation of which is:

$$C = 0.00092\,H \qquad (4)$$

Now, by substituting equation (4) in equation (3) we have the general equation which expresses "Y_o" as a function of "H" and "T"; that is:

$$Y_o = 0.00092\ H \times 10^{0.0159\,T} \qquad (5)$$

Chart No. 9

$$X_o = f(H)$$

The values of "X_o" from charts numbered 1 to 7 inclusive and the corresponding values of "H" were used to plot the points "H", "X_o", on logarithmic paper, as a curve drawn through them on this type of paper is a straight line the equation of which is of the form:

$$X_o = CH^n$$

in which:

n = slope of the line
C = value of "X_o" when "H" = 1

The average numerical value of "n", calculated by substituting the values of the points "H", "X_o", in the two point slope equation, was found to be:

$$n = 0.071598$$

Then, by substituting the value of "n" in the equation given above, we have:

$$X_o = CH^{0.071598}$$

The average numerical value of the constant "C" obtained by substituting the values of the points "H", "X_o" in the equation given above and solving for "C" was found to be:

$$C = 51.65$$

Then, by substitution, the general equation which expresses "X_o" as a function of "H" becomes:

$$X_o = 51.65\,H^{0.071598} \qquad (6)$$

or, in other words, if the per cent relative humidity is maintained at "X_o" for any observed heating value "H" the correction for humidity is zero.

The General Equation

From equation (2):

$$Y = -\frac{Y_o}{X_o} X + Y_o \qquad (2)$$

in which:

Y = humidity correction
X = per cent relative humidity
Y_o = value of "Y" when "X" = 0
X_o = value of "X" when "Y" = 0

Now, from equation (5):

$$Y_o = 0.00092\,H \times 10^{0.0159\,T} \qquad (5)$$

and from equation (6):

$$X_o = 51.65\,H^{0.071598} \qquad (6)$$

Then, by substitution, equation (2) becomes the general equation, also referred to as McGlashen's equation:

$$Y = -\frac{0.00092\,H \times 10^{0.0159\,T}}{51.65\,H^{0.071598}} X + 0.00092\,H \times 10^{0.0159\,T} \qquad (7)$$

in which:

Y = humidity correction in B.t.u.
X = per cent relative humidity
T = air temperature in ° F.
H = observed heating value in B.t.u.

all of which are known values, having been obtained by the operator during the test.

The combination chart numbered (8-1) (9-1) is presented for the rapid solution of McGlashen's equation (7) as well as equations (5) and (6).

The general equation (7) may also be written in the form:

$$Y = \frac{0.00092\,H \times 10^{0.0159\,T}}{51.65\,H^{0.071598}} \left(51.65\,H^{0.071598} - X\right) \qquad (7)$$

which is the form used by Edward H. Mohr,* in the construction of the "Z" chart, No. 11, which is made a part of this report.

Discussion

Although the data from which the general equation was deduced may be considered to be somewhat limited, it is demonstrated, by a comparison between the broken line curves which express the results of solving equation numbered (7), and the solid black curves drawn to express the given data on charts numbered 1 to 7 inclusive, that the process of interpolating a continuous series of points between the given values has introduced no appreciable error. It is also evident that the discrepancies are very small except in a few instances, which may, very likely, be affected by experimental error and, in all cases are of such magnitude that they would probably be disregarded in industrial gas calorimetry.

* Note: In order to illustrate the degree of concordance between the empirical equations written on each curve and the final general equation, the curves which express equation numbered (7) are shown on the same charts as the experimental data by broken lines.

* Los Angeles Gas and Electric Corp.

Answer these questions *with Klixon All Gas Controls...*

and your Heater-Sales will go up

You can sell more heaters per building with built-in Klixon Thermostats. For with Klixon controlled heaters you can provide uniform heat **throughout a building.** Each heater is safe and automatic—each heater is regulated to the needs of the room. You give your customers an even heat—a healthful heat—a heat that will build up sales.

Furthermore with Klixon Thermostats you offer gas companies a thermostat that they can service—a thermostat that they prefer to sell. For Klixon Thermostats are gas-actuated—no electric wiring is used. And Klixon has the **only** complete line of gas-actuated thermostats—wall thermostats for remote control; diaphragm thermostats for integral control; and safety pilots for safe lighting and operation.

Klixon Thermostats are extremely accurate, simple in operation and can be applied to practically any heater at low cost.

Send for bulletin.

KLIXON

TRADE MARK REG. U.S. PAT. OFF.

SPENCER THERMOSTAT COMPANY
ATTLEBORO, MASSACHUSETTS

CHART NO. 1

$y = mx + y_o$

OBSERVED HEATING VALUE 2000 B.T.U.

$X = y_o \div m = 89.0$

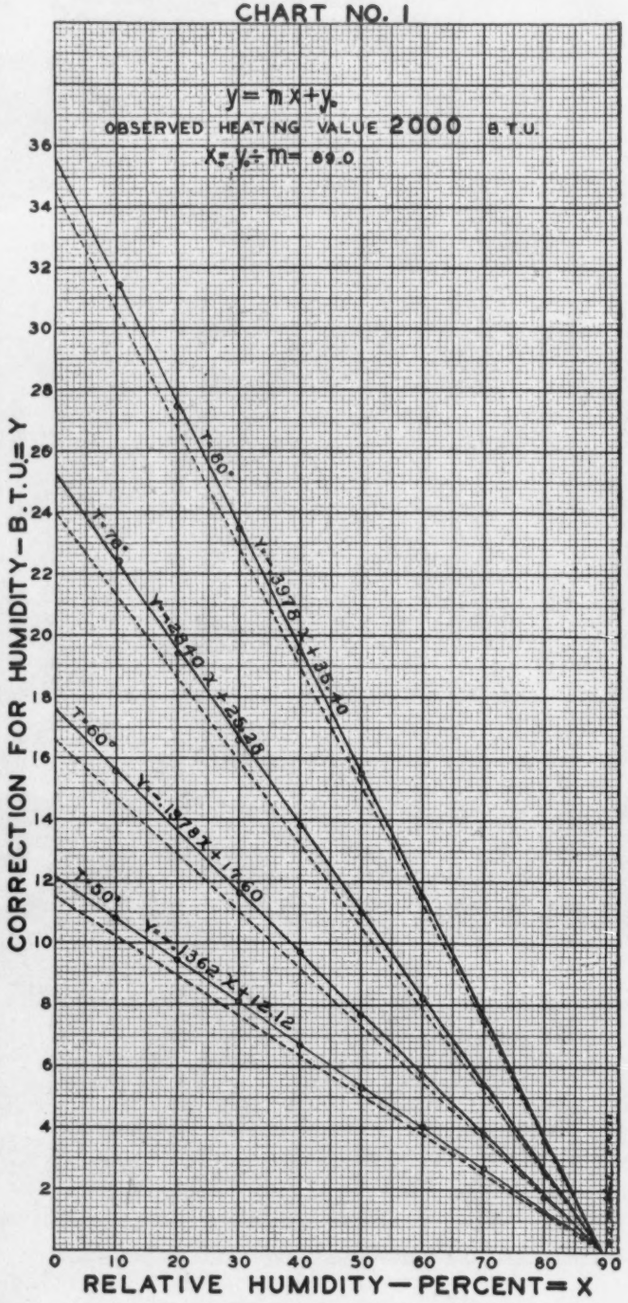


CHART NO. 2

$y = mx + y_o$

OBSERVED HEATING VALUE 1700 B.T.U.

$X = y_o \div m = 86.8$

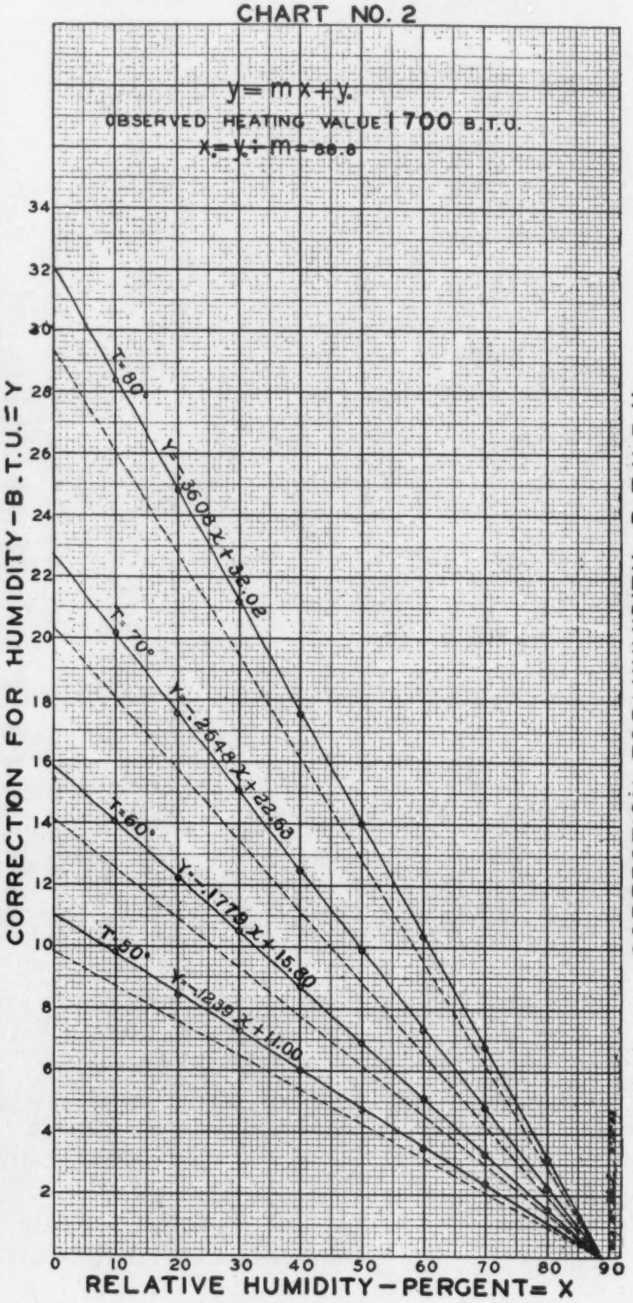
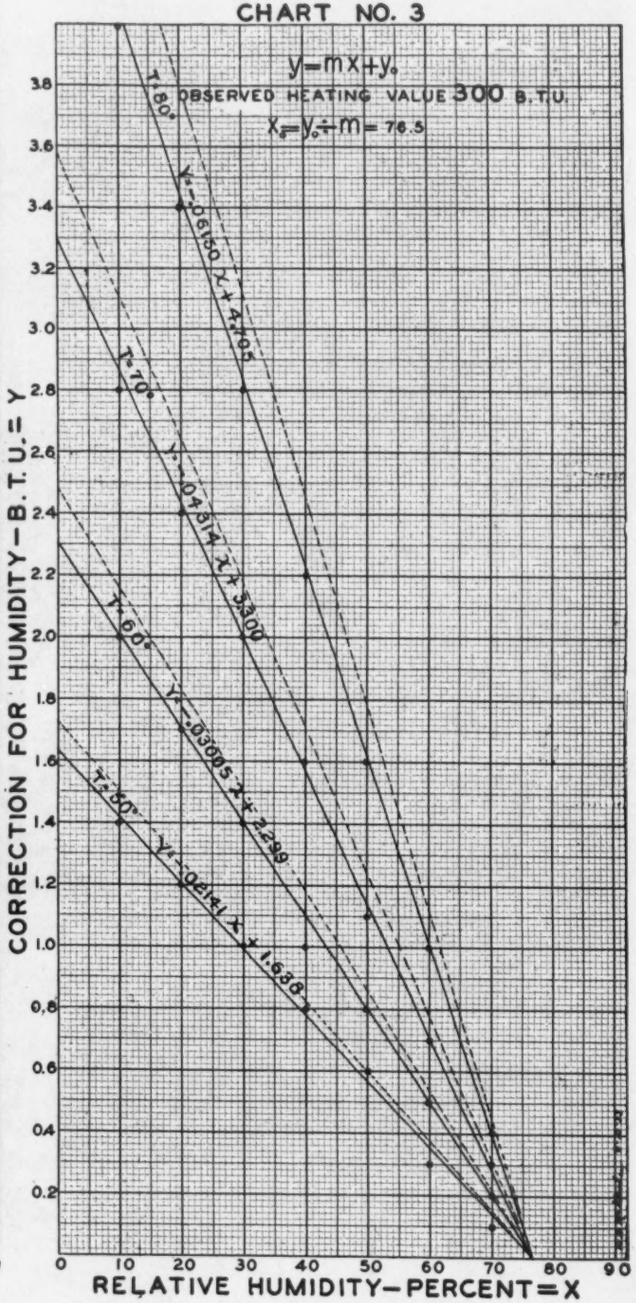


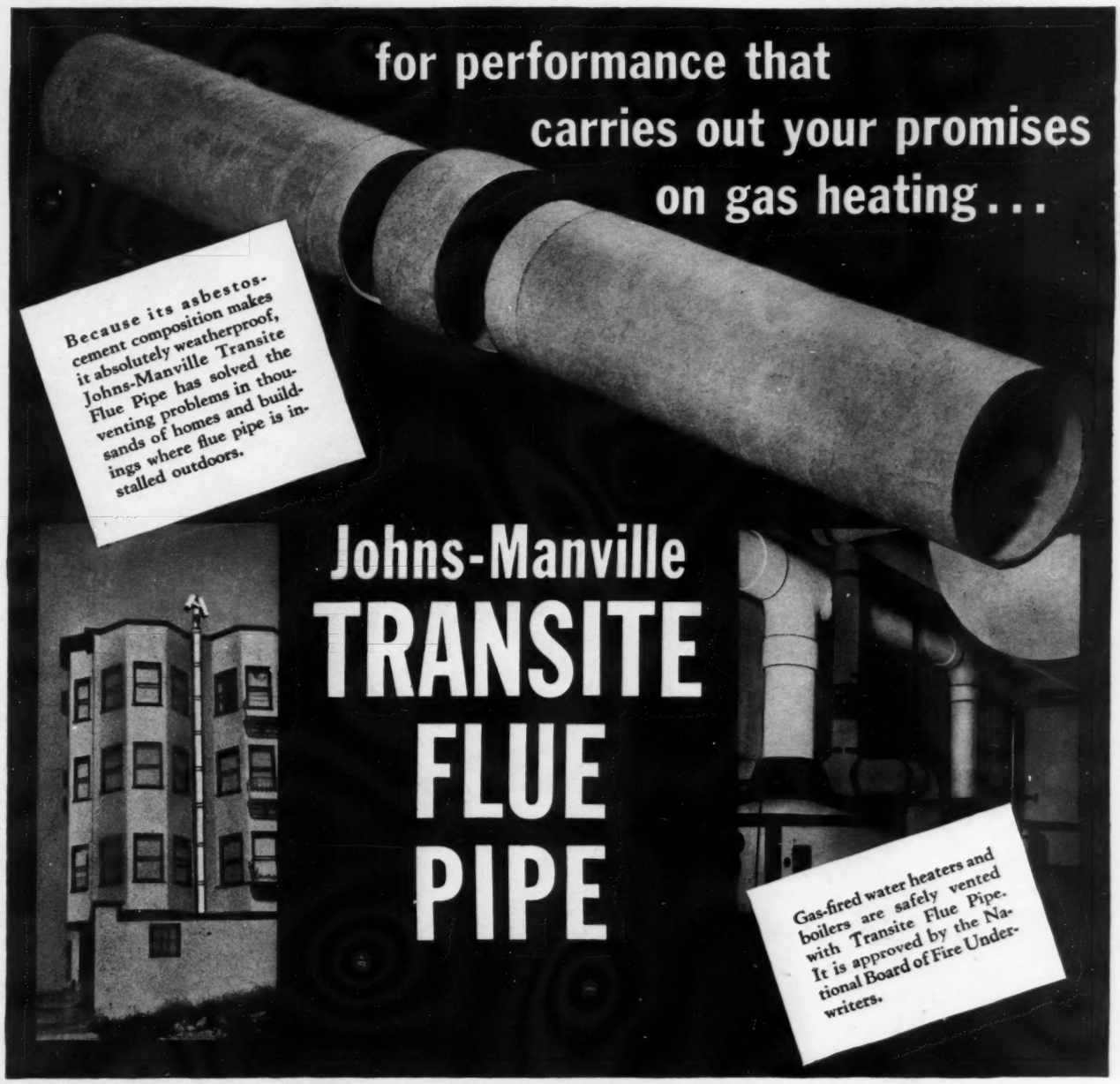
CHART NO. 3

$y = mx + y_o$

OBSERVED HEATING VALUE 300 B.T.U.

$X = y_o \div m = 76.5$




for performance that
carries out your promises
on gas heating...
Because its asbestos-cement composition makes it absolutely weatherproof, Johns-Manville Transite Flue Pipe has solved the venting problems in thousands of homes and buildings where flue pipe is installed outdoors.
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TRANSITE
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Gas-fired water heaters and boilers are safely vented with Transite Flue Pipe. It is approved by the National Board of Fire Underwriters.

Permanent, non-corrodible, weatherproof ... and surprisingly inexpensive

FOR gas heating you can rightly promise more convenience, greater dependability. To make sure its performance carries out these promises, the appliances and equipment used should be in the permanently trouble-proof, maintenance-free class.

Ending repair and replacement of corroded flue pipe and chimney linings is a matter of specifying J-M Transite Flue Pipe on all installations.

An asbestos-cement product, Transite Flue Pipe is remarkably resistant to corrosive fumes and condensates. Furthermore, Transite's low heat conductivity keeps stack temperatures at a high level for longer distances, minimizing condensation in the flue. Like all asbestos products, it is unusually resistant to high temperatures.

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G-8-36

Appliance
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REDUCED RATES • LOWER OPERATING COSTS
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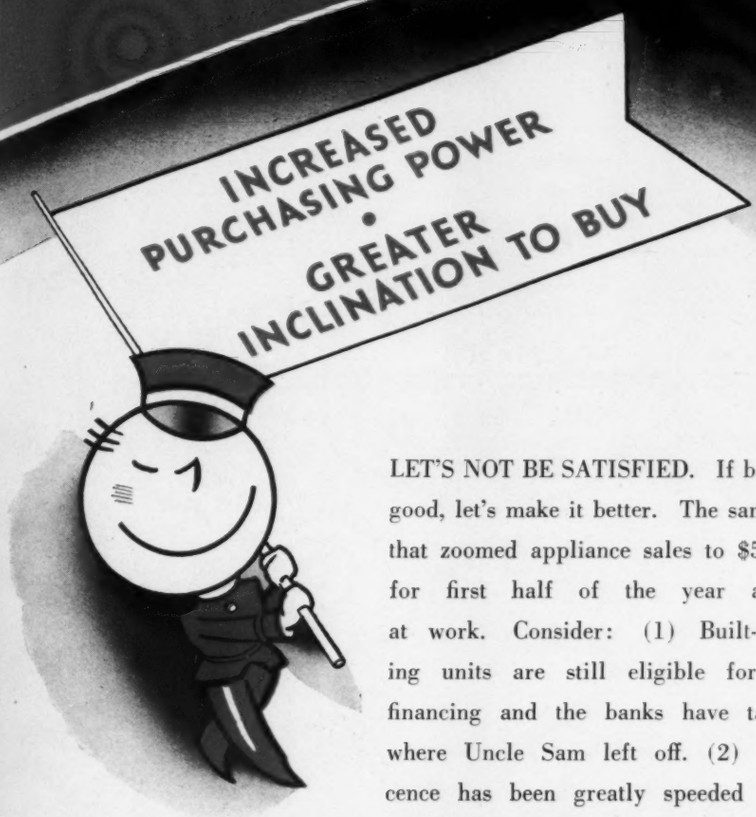
IMPROVEMENTS • REFINEMENTS • NEW FEATURES

PARADE FOR 1936



LET'S NOT BE SATISFIED. If business is good, let's make it better. The same forces that zoomed appliance sales to $5,000,000 for first half of the year are still at work. Consider: (1) Built-in heating units are still eligible for F.H.A. financing and the banks have taken up where Uncle Sam left off. (2) Obsolescence has been greatly speeded by new mechanical features and radical improvements in styling, color and design. So there is a vast replacement market to work on. (3) People have shown and are showing a greater inclination to buy, to spend money. And the majority of people have more money to spend. (4) Depression and competition have sharpened manufacturing methods with the result that greater and greater values are being offered the buying public. (5) The new economy-of-operation brought about by our May rate reduction is still live news. Moreover, we have the means of translating the new low rates into Hourly Operating Costs.* The P. G. and E. sales promotional "road show," on its recent tour of the system, presented a graphic picture of these Forces and called it the OPPORTUNITY PARADE FOR 1936. Dealers who attended our meetings were urged to line up behind this parade and "go to town." We can do no more than repeat in print what we have said in person. Except to add that the Company will be in the forefront—leading the way with a genuinely cooperative program of advertising and dealer sales promotion.

* **HEATING COST CALCULATOR**—a handy slide-rule device for computing the hourly operating costs of all types of gas-heating appliances. Figures are all based on the new low rates. A supply is available to dealers and dealer salespeople. See your local P. G. & E. office or write P. G. and E., 245 Market St., San Francisco.

P·G·and E·

PACIFIC GAS AND ELECTRIC COMPANY

OWNED · OPERATED · MANAGED BY CALIFORNIANS

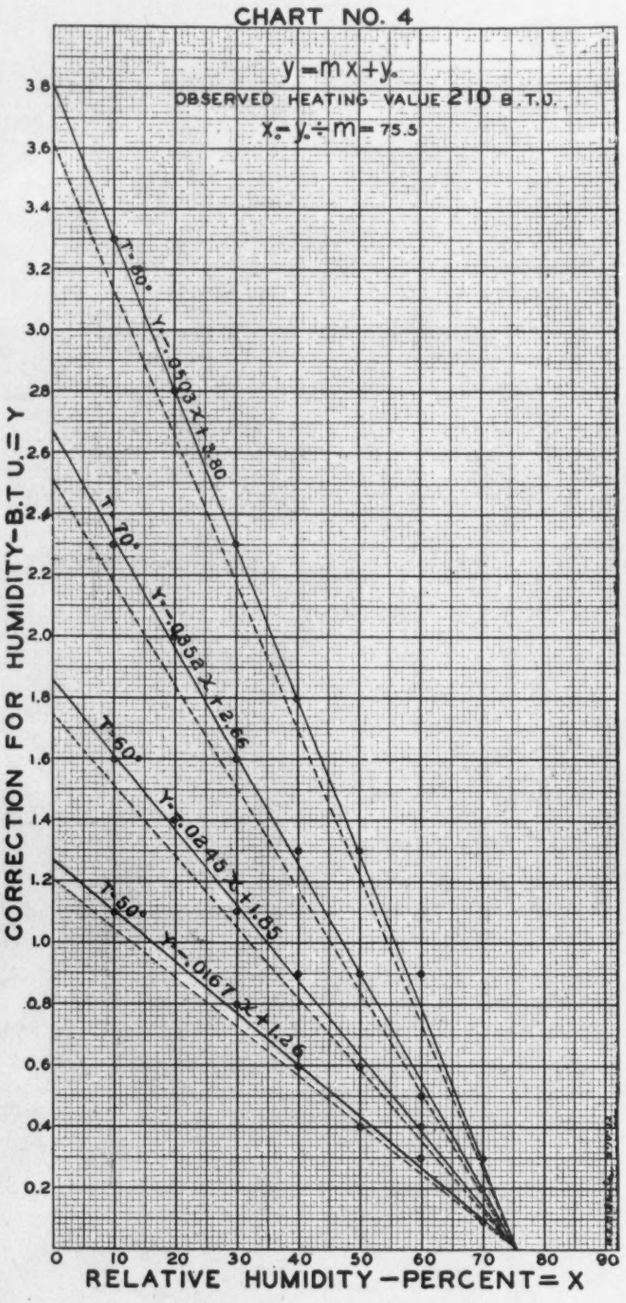


CHART NO. 4
y = m x + y₀
OBSERVED HEATING VALUE 210 B.T.U.
x = y₀ ÷ m = 75.5
T=80° Y=.0503X+3.80
T=70° Y=.0352X+2.66
T=60° Y=.0245X+1.85
T=50° Y=.0167X+1.26
CORRECTION FOR HUMIDITY-B.T.U.= Y
RELATIVE HUMIDITY-PERCENT= X

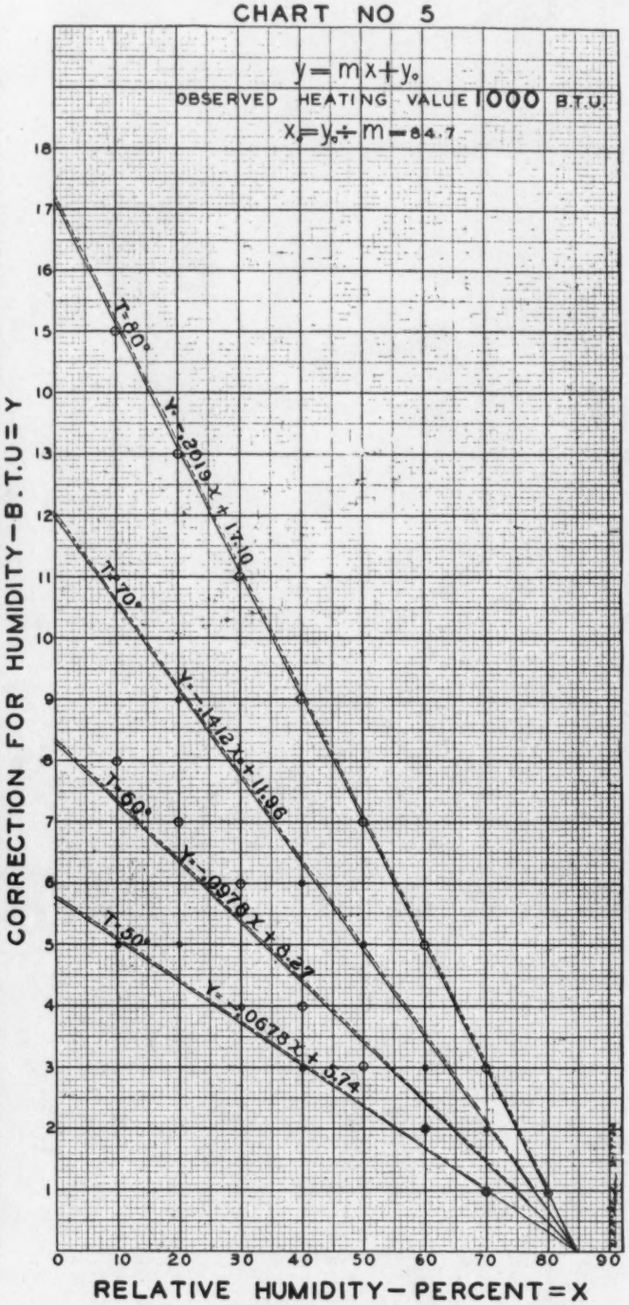


CHART NO 5
y = m x + y₀
OBSERVED HEATING VALUE 1000 B.T.U.
x = y₀ ÷ m = 84.7
T=80° Y=.2019X+17.10
T=70° Y=.1412X+11.96
T=60° Y=.0978X+8.27
T=50° Y=.0675X+5.74
CORRECTION FOR HUMIDITY-B.T.U.= Y
RELATIVE HUMIDITY-PERCENT= X

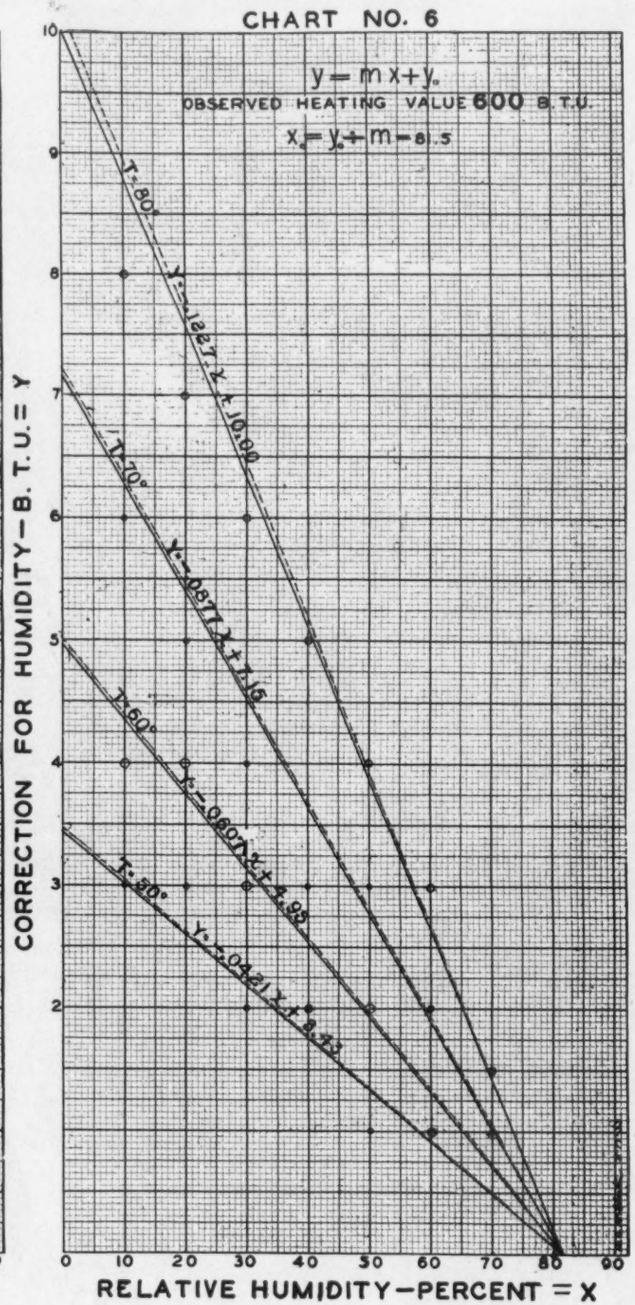
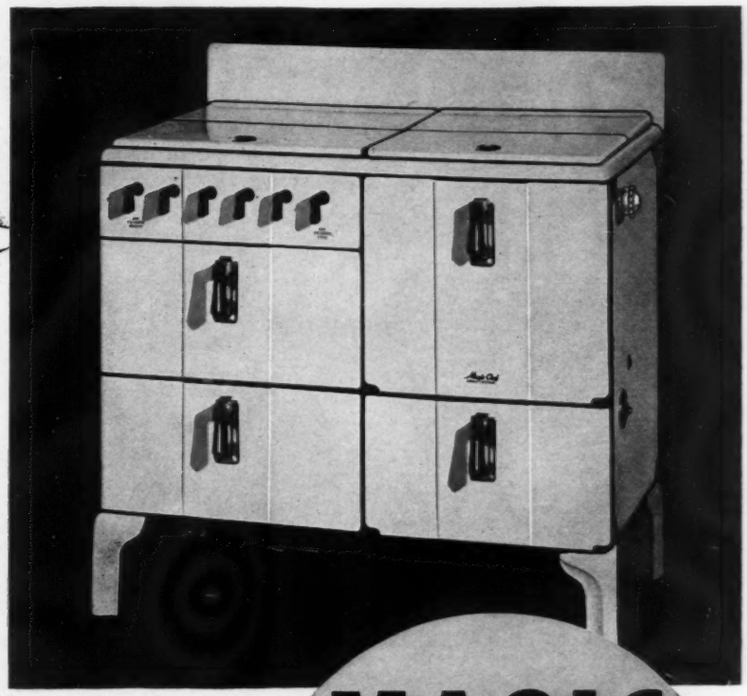


CHART NO. 6
y = m x + y₀
OBSERVED HEATING VALUE 600 B.T.U.
x = y₀ ÷ m = 81.5
T=80° Y=.1227X+10.00
T=70° Y=.0877X+7.15
T=60° Y=.0607X+4.95
T=50° Y=.0421X+3.43
CORRECTION FOR HUMIDITY-B.T.U.= Y
RELATIVE HUMIDITY-PERCENT = X



MAGIC CHEF

...has everything Mrs. Modern wants

MAGIC CHEF
GAS RANGE
SERIES 2500

● Magic Chef is the gas range Mrs. Modern is buying today because it typifies and embodies everything she admires and wants in a modern range. It embodies her ideas of present day style and beauty, measures up to her standards of convenience and efficiency, fully meets her requirements of service and economy.

Magic Chef sets a safe course for Mrs. Modern in buying a gas range because of its unquestioned leadership in design, advanced features, genuine quality and dependable performance. It sets a true course in gas range selling for gas companies and retailers because it keeps abreast of changing conditions in the cooking appliance field, grades up and sustains the market in quality gas ranges, builds up and holds consumer confidence necessary to successfully meet competition.

With all these advantages Magic Chef also has the *plus* of National Advertising to strengthen the position of the gas company and make its selling job easier.

LOOK FOR THE RED WHEEL
WHEN YOU BUY A MAGIC CHEF

[When you attend the Pacific Coast Gas Association Meeting the week of August 24th, be sure to visit us at our new warehouse location
424 Townsend Street, San Francisco, California]

AMERICAN STOVE COMPANY
BOSTON • NEW YORK • ATLANTA • CLEVELAND • CHICAGO
ST. LOUIS • PHILADELPHIA • SAN FRANCISCO • LOS ANGELES

Magic Chef
AMERICAN STOVE COMPANY

NOTE:- ——o——o—— X_o = THE 'X' INTERCEPT CHARTS NO. 1 TO 7 INCL.

——— $X_o = 51.65\ H^{0.071598}$ = THE RELATIVE HUMIDITY WHEN THE CORRECTION FOR HUMIDITY = 0.

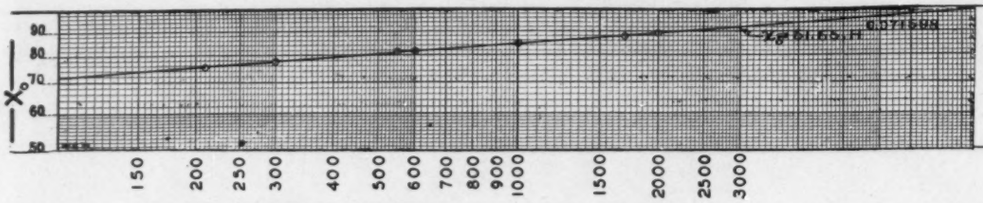
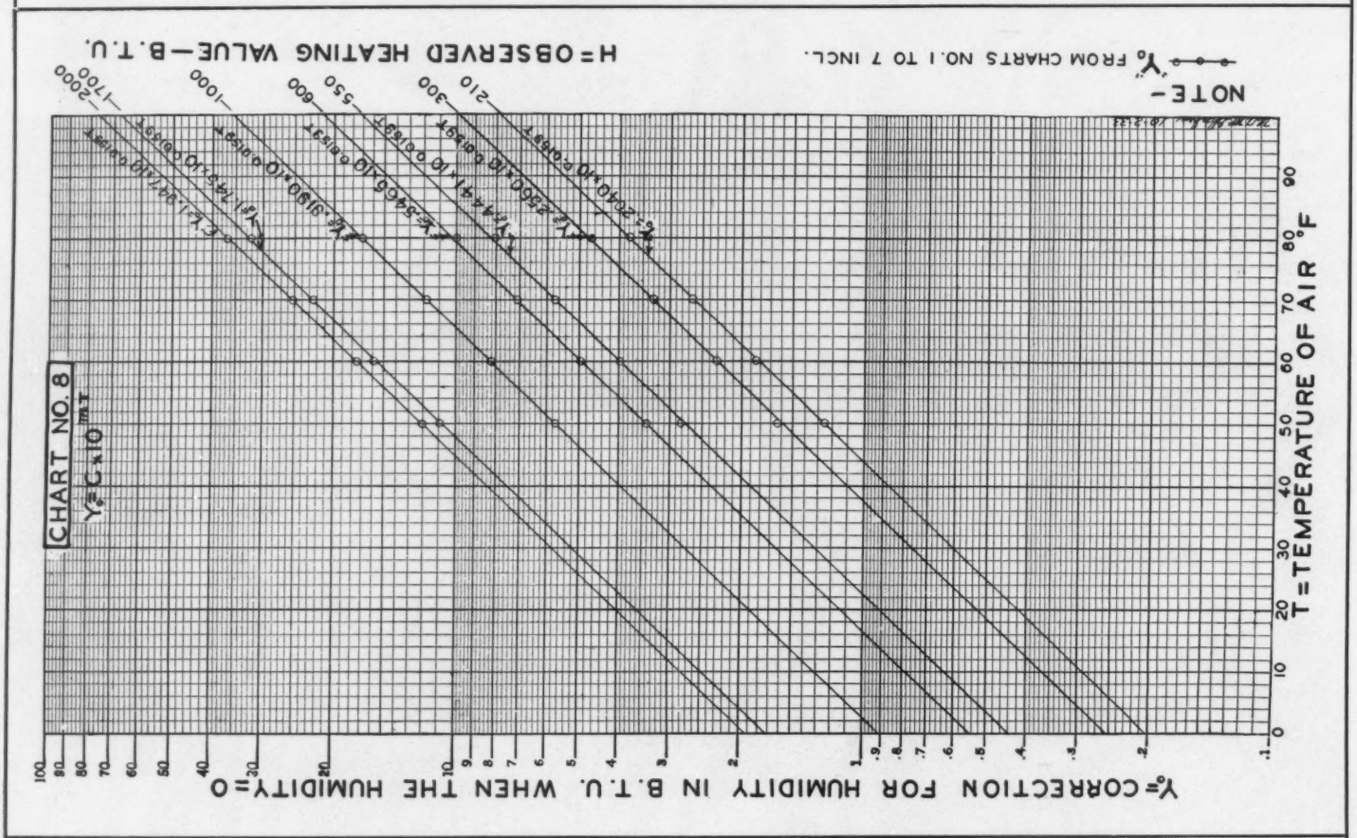


CHART NO. 9

$X_o = C \cdot H^n$


NOTE -
Y_o FROM CHARTS NO. 1 TO 7 INCL.
H = OBSERVED HEATING VALUE — B.T.U.
CHART NO. 8
$Y = C \cdot 10^{mT}$
Y = CORRECTION FOR HUMIDITY IN B.T.U. WHEN THE HUMIDITY = 0
T = TEMPERATURE OF AIR °F

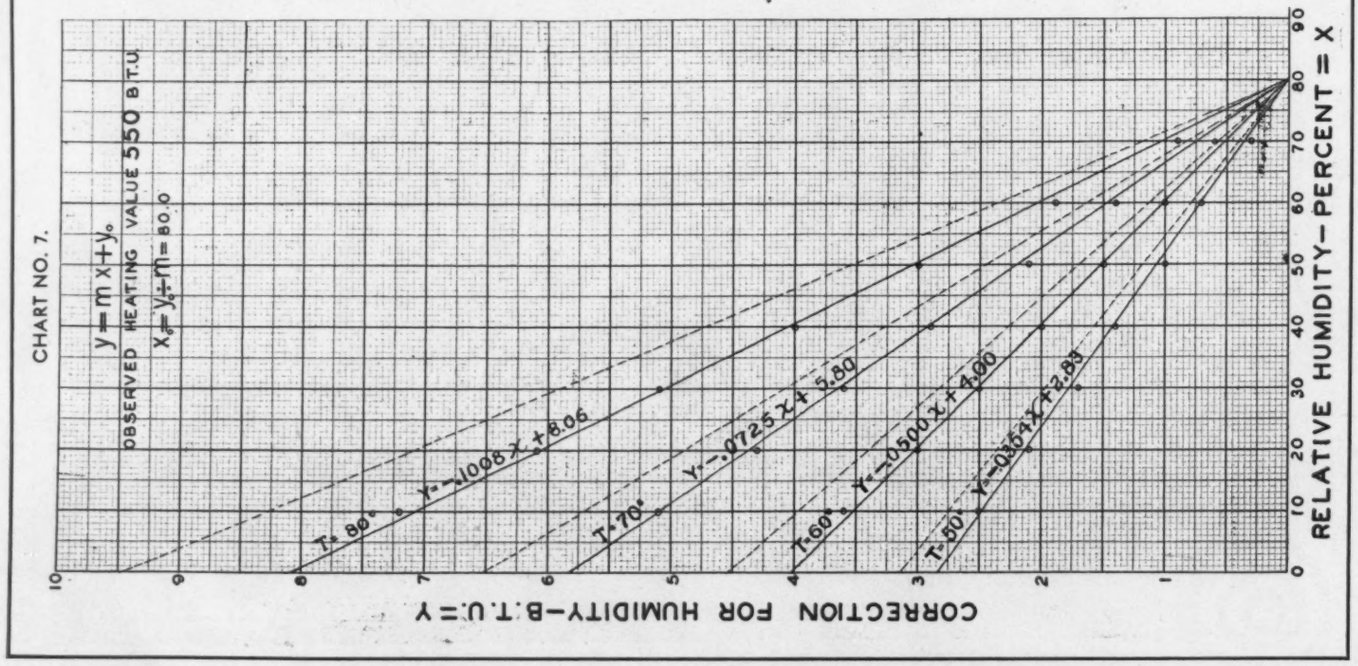
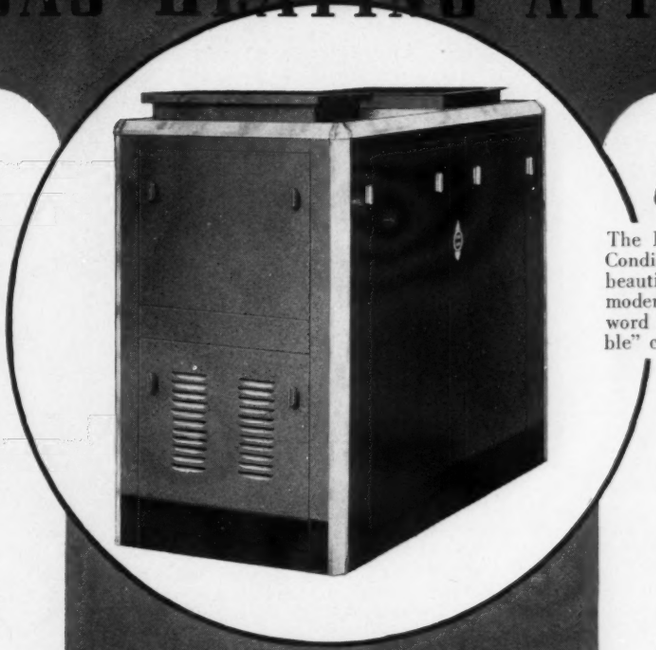


CHART NO. 7.
$y = mx + y_o$
OBSERVED HEATING VALUE 550 B.T.U.
$X_o = y_o \div m = 80.0$
T = 80° Y = -.1008 X + 8.06
T = 70° Y = -.0725 X + 5.80
T = 60° Y = -.0500 X + 4.00
T = 50° Y = -.0354 X + 2.83
CORRECTION FOR HUMIDITY — B.T.U. = Y
RELATIVE HUMIDITY — PERCENT = X

A

Well Balanced

LINE OF GAS HEATING APPLIANCES



The New Payne Modern Console Heater with grained walnut finish, built in thermostat control, the front discharge and superior heating and air circulating features greatly increases circulator sales.

Payne products can help you win the security of Complete Customer Satisfaction

★ More gas companies select Payne Products for their heating campaigns because they find in the Payne line a well designed gas appliance for every heating requirement. Whether the problem is single room heating or air conditioning an entire building it can be accomplished better with Payne Gas-fired equipment.

All Payne appliances are *gas-fired*. Each product has been created with the sole desire to broaden the scope of the gas heating industry and to increase the popularity of gas for heating.

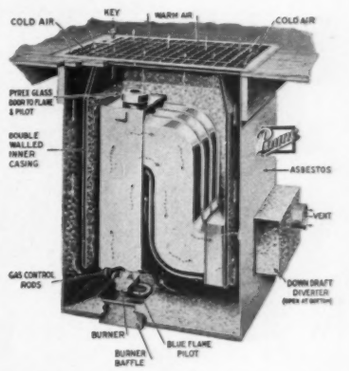
The completeness of the Payne line is evidence of what has been accomplished toward this end. The fact that more gas companies have chosen Payne appliances to feature in heating campaigns is proof of the customer satisfaction and good will that results from the sale and installation of a product of merit.

There is a more selective load building range in Payne heating equipment than will be found in any other line of gas heating products.

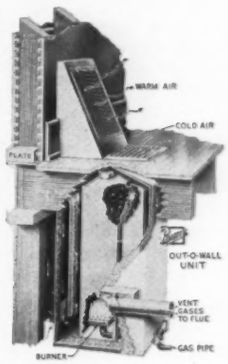
Write now for descriptive literature.

WINTER *Air Conditioner*

The Payne name plate on the New Winter Air Conditioner is your guarantee that enclosed in the beautiful casing is a unit embodying the most modern features and designed to provide the last word in automatic, controlled comfort and "durable" customer satisfaction.



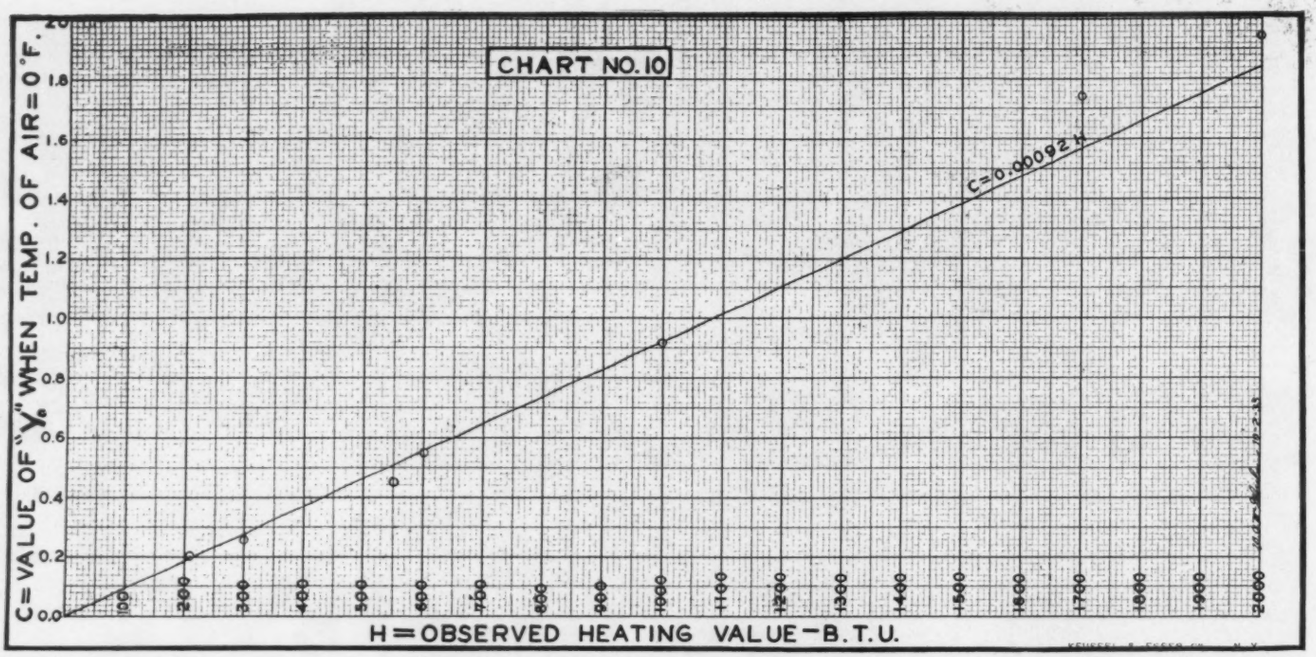
The Payne Floor Furnace has always been a leader in the gas heating field. As an efficient means for heating single or groups of rooms in the small home, it has no equal.



For the home where floor space must be conserved, the Payne Single Register Furnace offers an efficient and inexpensive way to heat single or connecting rooms. Installed like a Floor Furnace . . . no cutting of wall necessary.

PAYNE FURNACE & SUPPLY COMPANY

BEVERLY HILLS, CALIFORNIA



Therefore, the empirical equation numbered (7) which has been derived from the results of the experiments by different investigators is adequate for determining the humidity corrections when the calorimeter is operated under the conditions specified in such tests for gases of the same observed heating value as that used in the original experiments, and for all gases the observed heating value of which falls between the minimum and maximum of that used in the original experiments.

Although the process of extrapolation—that is, extending the curve beyond the range of the given values, is sometimes considered dangerous, the writer believes that, in this particular case, the curve may be extended in safety and that the equation numbered (7) is still valid for observed heating values above 2000 B.t.u.

If the barometric height "P" differs considerably from 30 inches the corrections given by equation numbered (7) must be multiplied by 30/P before being applied to the observed heating value. As a general rule this correction would not be made unless it results in a change of 0.5 B.t.u.

Summary

The general empirical equation numbered (7) is adequate for determining the humidity correction for any observed heating value obtained with a flow calorimeter when the calorimeter is operated under the conditions listed below.

The empirical equation numbered (6) is adequate for determining the per cent relative humidity of the air at which the flow calorimeter may be operated in order that the humidity correction be zero, when the calorimeter is operated under the conditions listed below.

The above mentioned empirical equations are valid only when the calorimeter is operated at the correct rate of gas consumption, and when the entering water, gas, air and the products of combustion are at approximately the same temperature.

The combination chart numbered (8-1) (9-1) is presented for the rapid solution of equations numbered (5), (6) and (7).

The "Z" chart, No. 11, is presented for the rapid solution of equation numbered (7).

PART TWO

THE DEVELOPMENT OF EMPIRICAL EQUATIONS FROM TEST DATA OF GROUP TWO

In addition to the data listed as available for the purpose of Part One of this report there has been published a method for the graphical determination of humidity corrections by E. X. Schmidt in "Gas Age-Record", September 24, 1932, under the title, "Making Accurate Heating Value Determinations on Gases." The corrections obtained by this method may be considered as theoretical corrections, since the location of the curves has been calculated from average gas analysis data, combustion constants, and data from steam tables. No general equation is given.

M. A. Richford, Pacific Gas and Electric Co., has published an equation in "Proceedings of P. C. G. A., 1934," for determining the humidity corrections for an observed heating value of 1179.1 B.t.u., which gives values in close agreement with those found by E. X. Schmidt's graphical method for that particular observed heating value.

In order that a proper comparison between the results of all methods for determining humidity corrections may be made the writer has, by the method given in Part One of this report, developed the following equations to express the results obtained by the use of E. X. Schmidt's method, as well as those resulting from the solution of M. A. Richford's equation.

The following notation is used:

Y = humidity correction in B.t.u.
X = per cent relative humidity of the air.
Y_o = value of "Y" when "X" = 0.
X_o = value of "X" when "Y" = 0.
T = temperature of the air in ° F.
H = observed heating value in B.t.u.

$$Y_o = (0.00135\,H - 0.24)\,10^{0.0154\,T} \qquad (5\text{-A})$$

It is suggested that special consideration be given to a comparison between the special empirical equations numbered (5) and (5-A) to determine if their difference may be charged to a difference in methods for determining "normal rates" and other basic values used in the original experiments and methods. A means of comparison will be suggested under the heading "Methods of Comparison."

$$X_o = 51.65\,H^{0.071598} \qquad (6\text{-A})$$

It will be noted that the special empirical equation numbered (6) developed in Part One of this report and the special empirical equation numbered (6-A) above are identical; that is, the equation may be used to determine the relative humidity of the combustion air "X_o" at which a flow calorimeter may be operated for any observed heating value "H" in order that the correction for humidity be zero.

It should not be difficult or expensive to arrange for saturation equipment so that the air for combustion could be maintained artificially at the temperature of the inlet water and room, at the relative humidity "X_o" for any observed heating value "H", and delivered to the calorimeter at atmospheric pressure, thus eliminating the need for humidity corrections even with variations in the volumes of excess air for combustion.

$$Y = -\frac{(0.00135\,H - 0.24)\,10^{0.0154\,T}}{51.65\,H^{0.071598}}X + (0.00135\,H - 0.24)\,10^{0.0154\,T} \qquad (7\text{-A})$$

BASO

ALTIMORE AUTOMATIC SHUT OFF

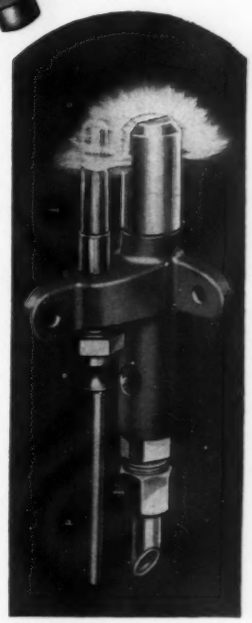
Models available: Gas Valve, sizes 3/8", 1/2", 3/4", 1" or 1-1/4". Two and three-wire low voltage switches for use with standard motor valves. Two-wire line voltage mercury tube switch, ten amperes 110 volts.

A THERMOCOUPLE!

● This extremely simple, two piece, all metal element made of an alloy rod inside an alloy tube, when bathed in a pilot flame at point "A", actually generates over an ampere of electric current — used by the BASO to energize an electromagnetic gas valve or control switch. When welded joint "A" (called the hot junction of the thermocouple) is heated about 500° F. above joints "B" (called the cold junctions of the thermocouple), more than ample electricity is generated. When the pilot is extinguished, the temperatures of junctions "A" and "B" equalize quickly. When the temperature difference decreases to about 200° F, the current weakens sufficiently to allow a strong spring to release the electromagnet allowing the valve or switch to snap off.

Since the generation of electricity depends solely upon a difference in temperature between junctions "A" and "B", the BASO will operate as fast in hot as in cooler combustion chambers. The shutting off takes place as soon as junctions "A" and "B" approach equalization so that "A" is not more than 200° F above "B". The Thermocouple need not cool to room temperature to effect the shut-off. If, for example, the temperature of both junctions were 1000° F, no electricity would be produced.

These phenomena assure that the BASO will operate just as fast in a gas furnace or conversion burner as it will in a domestic range or water heater.



MGSCo. bunsen pilots, especially built to locate thermocouple properly in pilot flame. Type No. 19119 shown, many other models available.

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MILWAUKEE
WISCONSIN

PACIFIC COAST REPRESENTATIVE
H. V. PAYNE, 3834 3rd Avenue,
LOS ANGELES, CALIF.

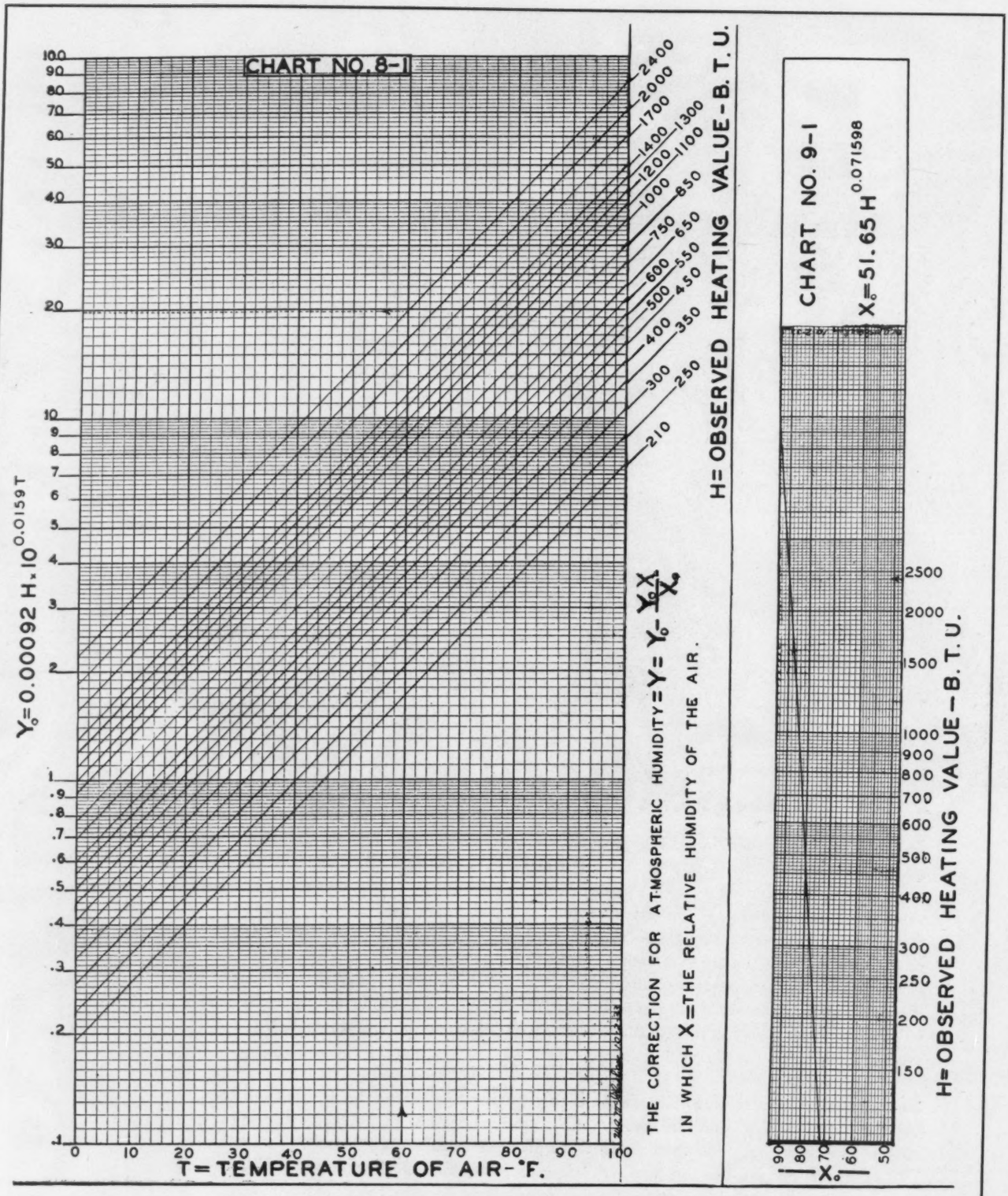


CHART NO. 8-1
$Y_o = 0.00092\ H \times 10^{0.0159\ T}$
T = TEMPERATURE OF AIR - °F.
H = OBSERVED HEATING VALUE - B.T.U.
THE CORRECTION FOR ATMOSPHERIC HUMIDITY $= Y = Y_o - \frac{Y_o X}{X_o}$
IN WHICH X = THE RELATIVE HUMIDITY OF THE AIR.
CHART NO. 9-1
$X_o = 51.65\ H^{0.071598}$
H = OBSERVED HEATING VALUE - B.T.U.
X_o

SOLUTION OF McGLASHEN'S EQUATION FOR

HUMIDITY CORRECTIONS,

TO BE APPLIED TO THE OBSERVED HEATING VALUES FOUND WITH FLOW CALORIMETERS

SAMPLE SOLUTION:

KNOWN DATA:- H = 2400 B.T.U. T = 60°F X = 50%

THE VALUES AS READ FROM THE ABOVE CHARTS (SEE DOTTED LINES) ARE:

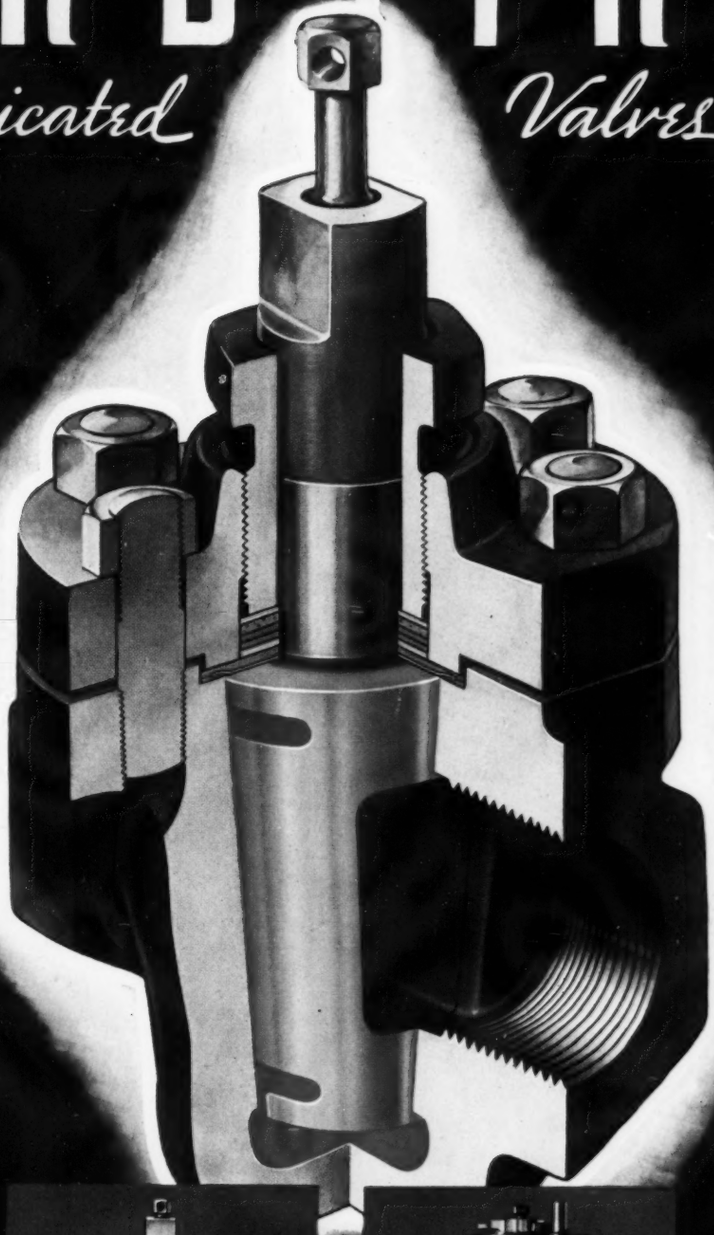
FROM CHART (8-1) $Y_o = 19.8$

FROM CHART (9-1) $X_o = 90.0$

THE HUMIDITY CORRECTION $Y = Y_o - \frac{Y_o X}{X_o} = 19.8 - \frac{19.8 \times 50}{90} = 8.8$ B.T.U.

NORDSTROM

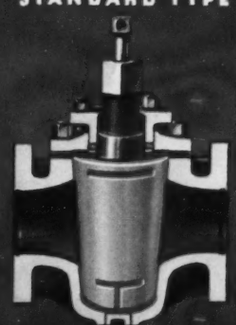
Lubricated Valves



EMCO-NORDSTROM TYPE

Round Opening
HYPRESEAL TYPE

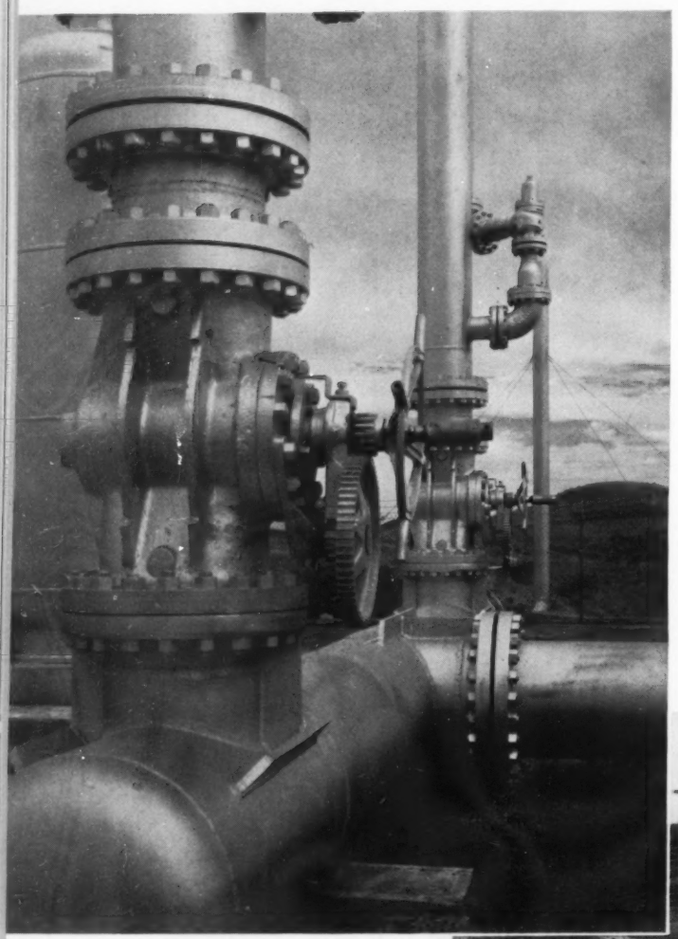
STANDARD TYPE



THE ENGINEERED VALVES FOR EVERY NEED. FREE-TURNING. LEAK-RESISTANT. CORROSION-RESISTANT. FOR WIDEST RANGE OF PRESSURES AND TEMPERATURES

HYPRESEAL TYPE

THE PERFECT APPLICATION OF A PRINCIPLE

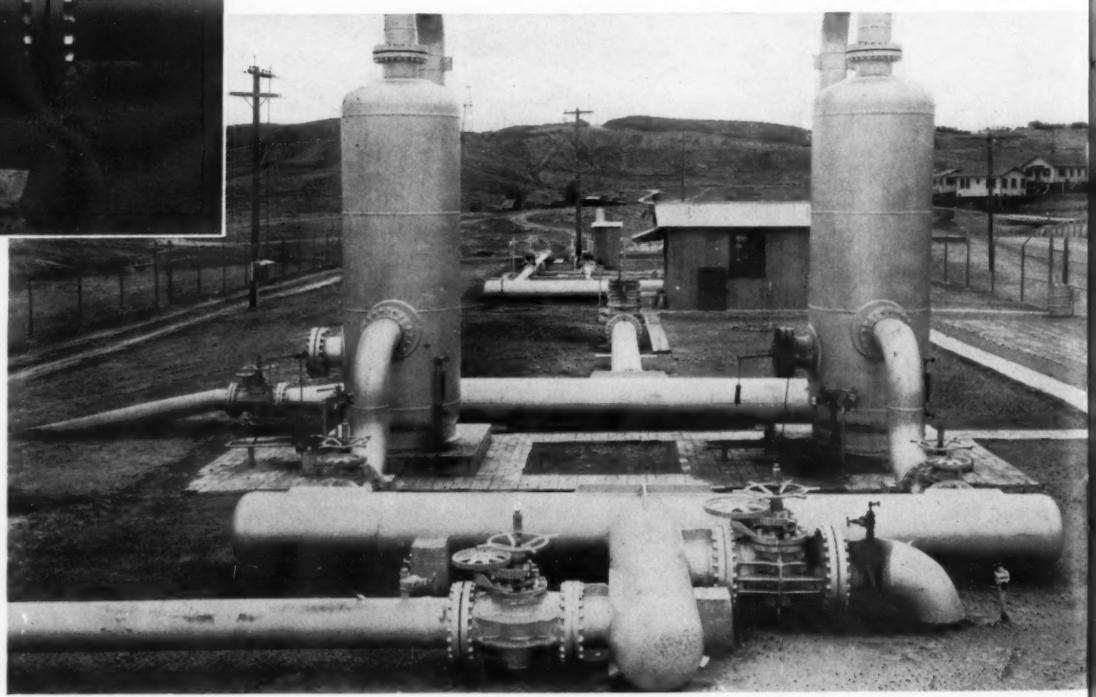


A GAS TRAP ISN'T MODERN UNLESS NORDSTROM-EQUIPPED

Intermittent pressures, corrosive elements, suspended dust and other elements encountered in gas trap lines are best controlled by Nordstrom Lubricated Valves. Regardless of line contents, these valves will shut tight, keep sealed, and are easily opened by a quarter-turn.

FOR PIPE LINE SERVICE

Practically all gas transmission, crude and gasoline lines laid during the past five years are equipped, in part at least, with Nordstrom Valves. For high-pressure service, Nordstroms are practically a necessity.



ONLY NORDSTROMS MEET EVERY MAJOR VALVE NEED

There's a type for each service. Sizes from ½" to 30". Choice of metals—cast iron, Nordco steel and special alloys.

Ask for Bulletin

MERCO NORDSTROM VALVE CO.
a subsidiary of
PITTSBURGH EQUITABLE METER CO.

Main Offices: Pittsburgh, Penna. Branch Offices: New York City, Buffalo, Philadelphia, Columbia, Memphis, Atlanta, Chicago, Kansas City, Tulsa, Houston, Los Angeles and Oakland.

NORDSTROM VALVES

LUBRICATED PLUG

PATENTED "SEALOPORT" LUBRICATION

A "Z" CHART

CONSTRUCTED BY EDWARD H MOHR FOR
THE SOLUTION OF McGLASHEN'S EQUATION NO. 7

HUMIDITY CORRECTIONS

TO BE APPLIED TO THE OBSERVED HEATING VALUE OBTAINED WITH FLOW CALORIMETERS

SAMPLE SOLUTION

KNOWN DATA— H = 2400 B T U T = 60 °F X = 50%

X_o FOR OBSERVED B T U = 90 $X_o - X = 90 - 50 = 40$ DRAW LINE (A) THRU T = 60 AND H = 2400 NOTE INTERSECTION WITH BALANCE LINE (B) DRAW LINE (C) THRU $X_o - X = 40$ AND POINT (B) READ THE HUMIDITY CORRECTION 88 B TU

	OBSERVED B T U IN HUNDREDS																							
FACTOR	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	FACTOR
X_o	75	78	79	81	82	83	83	84	85	85	86	86	87	87	88	88	88	89	89	89	90	90	90	X_o

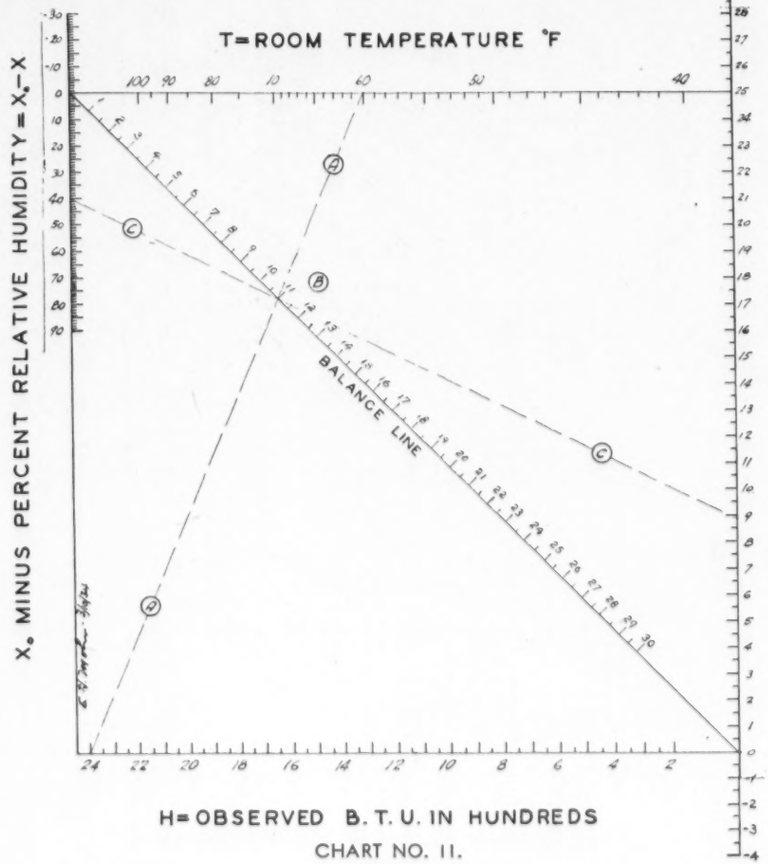

T = ROOM TEMPERATURE °F
100 90 80 70 60 50 40
BALANCE LINE
A
B
C
X₀ MINUS PERCENT RELATIVE HUMIDITY = X₀ − X
H = OBSERVED B. T. U. IN HUNDREDS

CHART NO. 11.

B. T. U. CORRECTION $Y = \frac{0.00092\ H\ 10^{0.0159\ T}}{51.65\ H^{0.071598}} \left(X_o - X\right)$ WHERE $X_o = 51.65\ H^{0.071598}$

A "Z" CHART

CONSTRUCTED BY EDWARD H. MOHR FOR
THE SOLUTION OF McGLASHEN'S EQUATION

NUMBERED 7-A

HUMIDITY CORRECTIONS

TO BE APPLIED TO THE OBSERVED HEATING VALUE OBTAINED WITH FLOW CALORIMETERS

SAMPLE SOLUTION

KNOWN DATA — H = 1180 B.T.U. T = 50 °F X = 20%

X_o FOR OBSERVED B.T.U. = 86 $X_o - X = 86 - 20 = 66$ DRAW LINE (A) THRU T = 50 AND H = 1180 NOTE INTERSECTION WITH BALANCE LINE (B) DRAW LINE (C) THRU $X_o - X = 66$ AND POINT (B) READ THE HUMIDITY CORRECTION Y = 6.2 B.T.U.

	OBSERVED B.T.U. IN HUNDREDS												
	6	7	8	9	10	11	12	13	14	15	16	17	18
FACTOR X_o	82	83	83	84	85	85	86	86	87	87	88	88	88

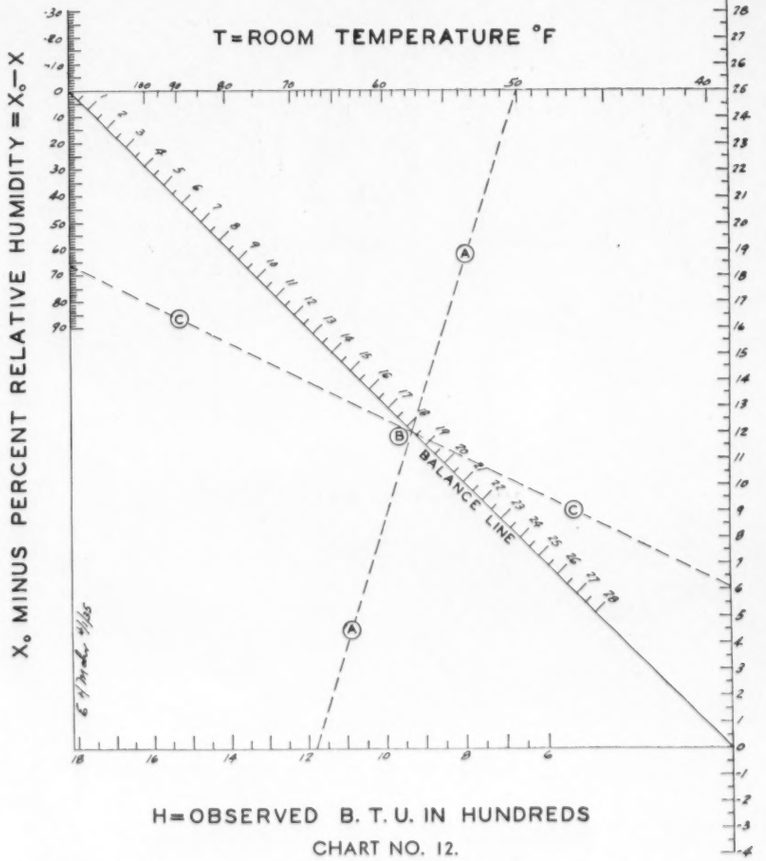

T = ROOM TEMPERATURE °F
100 90 80 70 60 50 40
BALANCE LINE
A
B
C
X₀ MINUS PERCENT RELATIVE HUMIDITY = X₀ − X
H = OBSERVED B. T. U. IN HUNDREDS

CHART NO. 12.

B. T. U. CORRECTION $Y = \frac{(0.00135\ H - 0.24)\ 10^{0.0154\ T}}{51.65\ H^{0.071598}} \left(X_o - X\right)$ WHERE $X_o = 51.65\ H^{0.071598}$

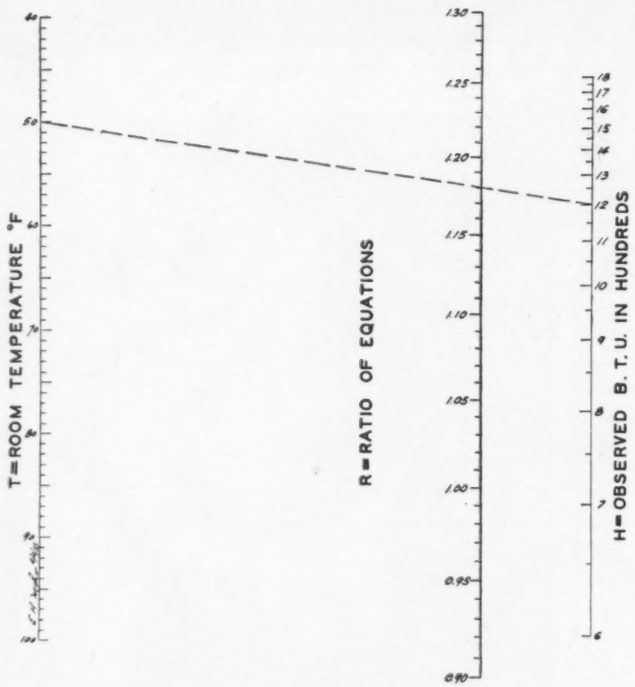


CHART NO. 13.

Alignment chart constructed by Edward H. Mohr for ratio comparison of McGlashen's Equations (7) and (7-A).

$$R = \text{Ratio} = \frac{\text{Eq. (7-A)}}{\text{Eq. (7)}} = \frac{\text{Eq. (5-A)}}{\text{Eq. (5)}} = \frac{(0.00135H-0.24)\ 10^{0.0154T}}{0.00092\ H\ \ 10^{0.0159T}}$$

Sample Solution:—Known Data: H = 1200 B.t.u.; T = 50°F.
Draw Line Through T = 50 and H = 1200; Read Ratio = 1.18.

It is obvious that the general empirical equation numbered (7) developed in part one of this report to express the results of experiments by the Bureau of Standards and Francis Fahey, and the general equation (7-A) developed to express the results of methods used by E. X. Schmidt and M. A. Richford are not in agreement and that their difference appears as a difference between the special empirical equations numbered (5) and (5-A).

The general equation numbered (7-A) may also be written in the form:

$$Y = \frac{(0.00135\ H - 0.24)\ 10^{0.0154\ T}}{51.65\ H^{0.071598}} (51.65\ H^{0.071598} - X) \qquad (7\text{-A})$$

which is the form used by Edward H. Mohr in the construction of the "Z" chart, No. 12, which is made a part of this report.

METHODS OF COMPARISON BETWEEN THE EQUATIONS OF PARTS ONE AND TWO

It is suggested that the "Z" charts for the solution of the general empirical equations numbered (7) and (7-A) be used as an aid in the comparison of the numerical differences between the results given by the solution of those equations, because of their labor saving features.

Edward H. Mohr has also constructed an alignment chart, No. 13, the solution of which gives the ratios of the values given by the special empirical equations numbered (5-A) and (5) as well as those given by the general equations numbered (7-A) and (7). This chart is made a part of this report because of its value in a study of the relative differences between the results given by the equations.

Following the above suggested procedure, Table No. 1 has been compiled and included in this report. This table demonstrates the use of "Z" chart readings to compare the results given by equation numbered (7-A) with a part of the data from which that equation was developed, as well as a comparison between the equations numbered (7) and (7-A) by the use of the alignment chart.

TABLES FOR HUMIDITY CORRECTION

Tables No. 2 to No. 7, inclusive, which give the humidity corrections for the observed heating values as designated, have been compiled by the use of equation (7).

TABLE NO. 1. COMPARISON CHART.

CORRECTIONS FOR HUMIDITY IN B T U WHEN OBSERVED HEATING VALUE=1180																													
AIR T.		40				50				60				70				80				90				100			
		A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
RELATIVE HUMIDITY-%	10	4.9	5.0	4.9	4.2	7.1	7.3	7.1	6.0	10.1	10.6	10.2	8.8	14.4	15.0	14.4	12.6	20.6	21.1	20.5	18.0	29.6	29.4	29.6	26.5	40.8	40.5	41.8	37.8
	20	4.3	4.4	4.3	3.7	6.1	6.4	6.2	5.2	8.8	9.2	8.9	7.6	12.4	13.1	12.5	11.0	17.9	18.4	17.8	15.7	25.7	25.7	25.6	23.0	35.4	35.5	36.3	32.8
	30	3.6	3.7	3.7	3.1	5.2	5.4	5.2	4.4	7.5	7.8	7.5	6.4	10.6	10.9	10.6	9.2	15.1	15.7	15.2	13.3	21.7	22.0	21.7	19.4	30.0	30.4	30.8	27.7
	40	3.0	3.1	3.0	2.5	4.3	4.5	4.3	3.7	6.1	6.5	6.3	5.3	8.7	9.2	8.7	7.7	12.4	13.0	12.5	11.0	17.9	18.2	17.8	16.1	24.7	25.3	25.3	22.8
	50	2.4	2.4	2.4	1.9	3.3	3.5	3.3	2.8	4.7	5.1	4.9	4.2	6.8	7.3	6.8	6.0	9.6	10.3	9.7	8.6	14.0	14.4	13.9	12.6	19.3	20.1	19.8	17.8
	60	1.7	1.8	1.7	1.4	2.4	2.6	2.4	2.0	3.4	3.7	3.5	3.1	4.9	5.3	4.8	4.3	7.0	7.5	7.0	6.2	10.0	10.6	10.0	9.2	13.8	14.8	14.3	13.0
	70	1.1	1.1	1.1	0.8	1.5	1.6	1.4	1.3	2.1	2.3	2.2	1.8	2.9	3.3	3.0	2.7	4.3	4.8	4.3	3.8	6.1	6.7	6.2	5.7	8.5	7.9	8.7	8.0
	80	0.4	0.4	0.4	0.3	0.6	0.6	0.5	0.5	0.8	0.9	0.9	0.7	1.2	1.3	1.1	1.0	1.6	2.0	1.7	1.4	2.3	2.8	2.2	2.2	3.1	4.0	3.4	3.2
RATIO	"Z" CHART		1.20				1.17				1.17				1.14				1.14				1.11				1.11		
	AL. CHART		1.19				1.18				1.16				1.15				1.14				1.12				1.11		

KEY

A—E. X. Schmidt's Data Interpreted for 1180 B.t.u.

B—M. A. Richford's Data for 1179.1 B.t.u.

C—"Z" Chart Solution of General Equation No. (7-A) for 1180 B.t.u.

D—"Z" Chart Solution of General Equation No. (7) for 1180 B.t.u.

$$\text{RATIO("Z" CHART)} = \frac{\Sigma C}{\Sigma D}$$

SALES CHART
May
June
July
Aug.
1936
1935
1934
All Records Smashed
AGAIN
DRAMATIC PROOF THAT
"DETROIT JEWEL" AND "GARLAND"
ARE AMERICA'S FASTEST SELLING
GAS RANGES
"Detroit Jewel" and "Garland" are the Gas Ranges most demanded by American housewives. Women want the error-free, economical operating stability recognized in "Detroit Jewel" and "Garland" efficiency.
If you want the proof, look at the 1936 sales charts of outlets selling them. Climaxing our first six months with a record breaking June, we've started the last six with a sensational record for July. We invite you to get in the "top flight" with us.
For the best Fall record of both volume and profits in your history, sell the best ranges in history. Write, wire or phone, and let's talk it over.
DETROIT-MICHIGAN
STOVE CO.
Detroit, Mich.

TABLE NO. 2. CORRECTION FOR HUMIDITY COMPILED BY USE OF McGLASHEN'S EQUATION (7).

CORRECTIONS FOR HUMIDITY IN B.T.U. WHEN OBSERVED HEATING VALUE IS 850 B.T.U.																										
AIR T.		40	45	50	55	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
RELATIVE HUMIDITY—PERCENT	0	3.4	4.1	4.9	5.9	7.0	7.6	8.1	8.8	9.4	10.1	10.9	11.7	12.6	13.6	14.6	15.7	16.9	18.2	19.6	21.1	22.7	24.4	26.3	28.3	30.4
	10	3.0	3.6	4.3	5.2	6.2	6.7	7.2	7.7	8.3	8.9	9.6	10.3	11.1	12.0	12.9	13.9	14.9	16.0	17.3	18.6	20.0	21.5	23.1	24.9	26.8
	20	2.6	3.1	3.7	4.5	5.4	5.8	6.2	6.7	7.2	7.7	8.3	8.9	9.6	10.3	11.1	12.0	12.9	13.9	14.9	16.1	17.3	18.6	20.0	21.5	23.2
	30	2.2	2.6	3.1	3.8	4.5	4.9	5.2	5.6	6.0	6.5	7.0	7.5	8.1	8.7	9.4	10.1	10.9	11.7	12.6	13.5	14.6	15.7	16.8	18.1	19.5
	40	1.8	2.1	2.5	3.1	3.7	3.9	4.2	4.6	4.9	5.3	5.7	6.1	6.6	7.1	7.6	8.2	8.8	9.5	10.2	11.0	11.8	12.7	13.7	14.7	15.9
	50	1.4	1.6	2.0	2.4	2.8	3.0	3.3	3.5	3.8	4.1	4.4	4.7	5.1	5.5	5.9	6.3	6.8	7.3	7.9	8.5	9.1	9.8	10.6	11.4	12.2
	60	1.0	1.1	1.4	1.7	2.0	2.1	2.3	2.5	2.7	2.9	3.1	3.3	3.6	3.8	4.1	4.4	4.8	5.1	5.5	6.0	6.4	6.9	7.4	8.0	8.6
	70	0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.5	1.5	1.7	1.8	1.9	2.1	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.7	4.0	4.3	4.6	5.0
	80	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.1	1.2	1.3
	83.6	At this humidity the correction is zero for all air temperatures. Corrections for humidity above 83.6 are positive.																								
	90	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.9	2.0	2.2	2.3
	100	0.7	0.8	1.0	1.1	1.4	1.5	1.6	1.7	1.8	2.0	2.1	2.3	2.5	2.7	2.9	3.1	3.3	3.6	3.8	4.1	4.4	4.8	5.2	5.5	6.0

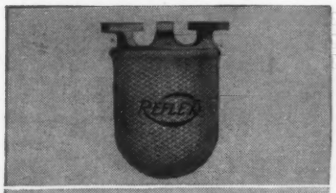
TABLE NO. 3. CORRECTION FOR HUMIDITY COMPILED BY USE OF McGLASHEN'S EQUATION (7).

CORRECTIONS FOR HUMIDITY IN B.T.U WHEN OBSERVED HEATING VALUE IS 950 B.T.U.																										
AIR T.		40	45	50	55	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
RELATIVE HUMIDITY—PERCENT	0	3.8	4.5	5.5	6.6	7.9	8.5	9.1	9.8	10.5	11.3	12.2	13.1	14.1	15.2	16.4	17.6	18.9	20.4	21.9	23.6	25.4	27.3	29.4	31.6	34.0
	10	3.3	4.0	4.8	5.8	6.9	7.5	8.0	8.6	9.3	10.0	10.8	11.6	12.5	13.4	14.4	15.5	16.7	18.0	19.3	20.8	22.4	24.1	25.9	27.9	30.0
	20	2.9	3.5	4.2	5.0	6.0	6.5	6.9	7.5	8.0	8.7	9.3	10.0	10.8	11.6	12.5	13.4	14.4	15.5	16.7	18.0	19.4	20.8	22.4	24.1	25.9
	30	2.4	2.9	3.5	4.2	5.1	5.5	5.9	6.3	6.8	7.3	7.9	8.5	9.1	9.8	10.5	11.3	12.2	13.1	14.1	15.2	16.4	17.6	18.9	20.4	21.9
	40	2.0	2.4	2.9	3.4	4.1	4.5	4.8	5.2	5.5	6.0	6.4	6.9	7.4	8.0	8.6	9.3	10.0	10.7	11.5	12.4	13.3	14.4	15.5	16.6	17.9
	50	1.5	1.9	2.2	2.7	3.2	3.5	3.7	4.0	4.3	4.6	5.0	5.4	5.8	6.2	6.7	7.2	7.7	8.3	8.9	9.6	10.3	11.1	12.0	12.9	13.9
	60	1.1	1.3	1.6	1.9	2.3	2.4	2.6	2.8	3.1	3.3	3.5	3.8	4.1	4.4	4.7	5.1	5.5	5.9	6.3	6.8	7.3	7.9	8.5	9.1	9.8
	70	0.6	0.8	0.9	1.1	1.3	1.4	1.6	1.7	1.8	1.9	2.1	2.2	2.4	2.6	2.8	3.0	3.2	3.5	3.7	4.0	4.3	4.7	5.0	5.4	5.8
	80	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.1	1.2	1.3	1.4	1.5	1.6	1.8
	84.4	At this humidity the correction is zero for all air temperatures. Corrections for humidity above 84.4 are positive.																								
	90	-0.3	-0.3	-0.4	-0.4	-0.5	-0.6	-0.6	-0.7	-0.7	-0.8	-0.8	-0.9	-0.9	-1.0	-1.1	-1.2	-1.3	-1.4	-1.5	-1.6	-1.7	-1.8	-2.0	-2.1	-2.3
	100	-0.7	-0.8	-1.0	-1.2	-1.5	-1.6	-1.7	-1.8	-2.0	-2.1	-2.3	-2.4	-2.6	-2.8	-3.0	-3.3	-3.5	-3.8	-4.1	-4.4	-4.7	-5.1	-5.4	-5.9	-6.3

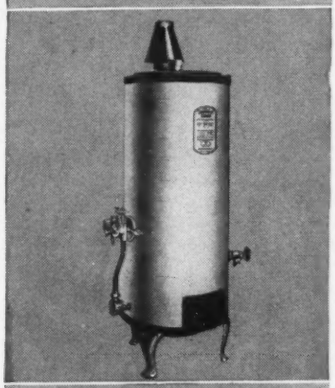
TABLE NO. 4. CORRECTION FOR HUMIDITY COMPILED BY USE OF McGLASHEN'S EQUATION (7).

CORRECTIONS FOR HUMIDITY IN B.T.U. WHEN OBSERVED HEATING VALUE IS 1050 B.T.U.																										
AIR T.		40	45	50	55	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
RELATIVE HUMIDITY—PERCENT	0	4.2	5.0	6.0	7.2	8.7	9.4	10.1	10.8	11.7	12.5	13.5	14.5	15.6	16.8	18.1	19.5	20.9	22.5	24.2	26.1	28.0	30.2	32.5	34.9	37.6
	10	3.7	4.4	5.3	6.4	7.7	8.3	8.9	9.6	10.3	11.1	11.9	12.8	13.8	14.8	15.9	17.2	18.5	19.9	21.4	23.0	24.7	26.6	28.6	30.8	33.2
	20	3.2	3.8	4.6	5.5	6.6	7.2	7.7	8.3	8.9	9.6	10.3	11.1	11.9	12.9	13.8	14.9	16.0	17.2	18.5	19.9	21.4	23.1	24.8	26.7	28.7
	30	2.7	3.3	3.9	4.7	5.6	6.1	6.5	7.0	7.5	8.1	8.7	9.4	10.1	10.9	11.7	12.6	13.5	14.6	15.7	16.9	18.1	19.5	21.0	22.6	24.3
	40	2.2	2.7	3.2	3.8	4.6	5.0	5.3	5.7	6.2	6.6	7.1	7.7	8.3	8.9	9.6	10.3	11.1	11.9	12.8	13.8	14.8	16.0	17.2	18.5	19.9
	50	1.7	2.1	2.5	3.0	3.6	3.9	4.1	4.5	4.8	5.2	5.6	6.0	6.4	6.9	7.4	8.0	8.6	9.3	10.0	10.7	11.5	12.4	13.4	14.4	15.5
	60	1.2	1.5	1.8	2.1	2.6	2.8	3.0	3.2	3.4	3.7	4.0	4.3	4.6	4.9	5.3	5.7	6.2	6.6	7.1	7.7	8.2	8.9	9.5	10.3	11.1
	70	0.7	0.9	1.1	1.3	1.5	1.7	1.8	1.9	2.1	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.7	4.0	4.3	4.6	4.9	5.3	5.7	6.2	6.6
	80	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.1	1.2	1.3	1.4	1.5	1.6	1.8	1.9	2.1	2.2
	85.0	At this humidity the correction is zero for all air temperatures. Corrections for humidity above 85.0 are positive.																								
	90	-0.3	-0.3	-0.4	-0.4	-0.5	-0.6	-0.6	-0.6	-0.7	-0.7	-0.8	-0.9	-0.9	-1.0	-1.1	-1.2	-1.2	-1.3	-1.4	-1.5	-1.7	-1.8	-1.9	-2.1	-2.2
	100	-0.7	-0.9	-1.1	-1.3	-1.5	-1.7	-1.8	-1.9	-2.1	-2.2	-2.4	-2.6	-2.8	-3.0	-3.2	-3.4	-3.7	-4.0	-4.3	-4.6	-5.0	-5.3	-5.7	-6.2	-6.6

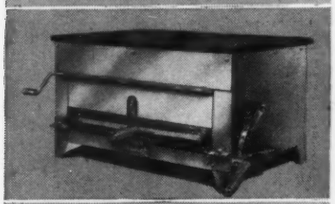
WELSBACH PRODUCTS



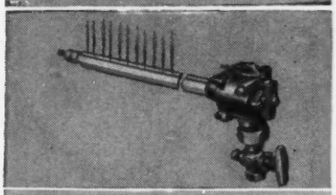
GAS MANTLE



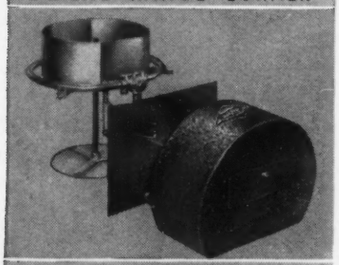
HOTZONE GAS WATER HEATER



HOTZONE BROILER-GRIDDLE



E-Z-LITE RANGE BURNER



HOTZONE FURNACE BURNER

WRITE TODAY FOR CATALOGS PRICES AND DETAILS ABOUT WELSBACH PRODUCTS

RELIABILITY
IS *earned*
NOT ANNOUNCED

IT takes more than a mere announcement to gain a reputation for reliability. It is a characteristic paid for with sacrifice and time. Only consumer acknowledgement of this distinction entitles public claim to this reputation.

SINCE 1887 Welsbach has stood for reliability, during that time pioneering in the manufacture of gas burning equipment with a constant view to efficiency and economy of operation. Only appliances which have fully met the claims of the manufacturer could continue to sell for nearly a half century.

WELSBACH'S pioneering work developed the HOTZONE gas water heater with its recognized high efficiency, the Radiant Broiler Burner, with its penetrating Infra Red Ray for cooking, and the luminous flame gas furnace burner with its silent heat for the home. Behind all these products stands Welsbach's well-earned reputation for reliable appliances produced with the technique which only a half century old experience can provide.

WRITE today for a Welsbach catalog. Get further details about the HOTZONE line.

WELSBACH COMPANY

GLOUCESTER CITY, N. J.

Branches in Chicago and San Francisco

Since 1887, Pioneers in the Manufacture of Gas Burning Appliances

TABLE NO. 5. CORRECTION FOR HUMIDITY COMPILED BY USE OF McGLASHEN'S EQUATION (7).

CORRECTIONS FOR HUMIDITY IN B.T.U. WHEN OBSERVED HEATING VALUE IS 1100 B.T.U.																									
AIR T.		40	45	50	55	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
RELATIVE HUMIDITY—PERCENT	0	4.4	5.3	6.3	7.6	9.1	9.8	10.5	11.3	12.2	13.1	14.1	15.2	16.4	17.6	18.9	20.4	21.9	23.6	25.4	27.3	29.4	31.6	34.0	36.6	39.4
	10	3.9	4.6	5.6	6.7	8.0	8.6	9.3	10.0	10.8	11.6	12.5	13.3	14.4	15.5	16.7	18.0	19.3	20.8	22.4	24.1	25.9	27.9	30.0	32.3	34.8
	20	3.4	4.0	4.8	5.8	7.0	7.5	8.1	8.7	9.3	10.0	10.8	11.6	12.5	13.5	14.5	15.6	16.8	18.1	19.4	20.9	22.5	24.2	26.0	28.0	30.1
	30	2.8	3.4	4.1	4.9	5.9	6.3	6.8	7.3	7.9	8.5	9.2	9.9	10.6	11.4	12.3	13.2	14.2	15.3	16.4	17.7	19.0	20.5	22.0	23.7	25.5
	40	2.3	2.8	3.4	4.0	4.8	5.2	5.6	6.0	6.5	7.0	7.5	8.1	8.7	9.3	10.1	10.8	11.6	12.5	13.5	14.5	15.6	16.8	18.1	19.4	20.9
	50	1.8	2.2	2.6	3.1	3.8	4.1	4.4	4.7	5.0	5.4	5.8	6.3	6.8	7.3	7.8	8.4	9.1	9.8	10.5	11.3	12.2	13.1	14.1	15.1	16.3
	60	1.3	1.6	1.9	2.2	2.7	2.9	3.1	3.4	3.6	3.9	4.2	4.5	4.8	5.2	5.6	6.0	6.5	7.0	7.5	8.1	8.7	9.4	10.1	10.8	11.7
	70	0.8	0.9	1.1	1.4	1.6	1.8	1.9	2.0	2.2	2.4	2.5	2.7	2.9	3.2	3.4	3.6	3.9	4.2	4.5	4.9	5.3	5.7	6.1	6.6	7.0
	80	0.3	0.3	0.4	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.0	2.1	2.3	2.4
	85.3	At this humfdity the correction is zero for all air temperatures. Corrections for humidity above 85.3 are positive.																								
	90	-0.2	-0.3	-0.4	-0.4	-0.5	-0.5	-0.6	-0.6	-0.7	-0.7	-0.8	-0.9	-0.9	-1.0	-1.1	-1.1	-1.2	-1.3	-1.4	-1.5	-1.6	-1.8	-1.9	-2.0	-2.2
	100	-0.8	-0.9	-1.1	-1.3	-1.6	-1.7	-1.8	-2.0	-2.1	-2.3	-2.4	-2.6	-2.8	-3.0	-3.3	-3.5	-3.8	-4.1	-4.4	-4.7	-5.1	-5.5	-5.9	-6.3	-6.8

TABLE NO. 6. CORRECTION FOR HUMIDITY COMPILED BY USE OF McGLASHEN'S EQUATION (7).

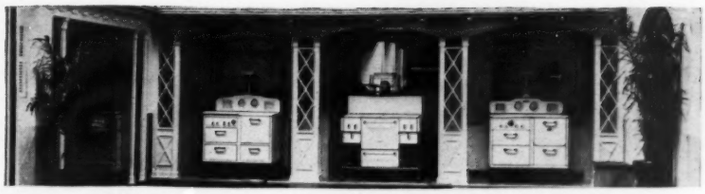
CORRECTIONS FOR HUMIDITY IN B.T.U. WHEN OBSERVED HEATING VALUE IS 1150 B.T.U.																									
AIR T.		40	45	50	55	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
RELATIVE HUMIDITY—PERCENT	0	4.6	5.5	6.6	7.9	9.5	10.2	11.0	11.9	12.8	13.7	14.8	15.9	17.1	18.4	19.8	21.3	22.9	24.7	26.5	28.5	30.7	33.0	35.6	38.3	41.2
	10	4.0	4.9	5.8	7.0	8.4	9.0	9.7	10.5	11.3	12.1	13.0	14.0	15.1	16.3	17.5	18.8	20.2	21.8	23.4	25.2	27.1	29.2	31.4	33.8	36.4
	20	3.5	4.2	5.1	6.1	7.3	7.9	8.4	9.1	9.8	10.5	11.3	12.2	13.1	14.1	15.2	16.3	17.6	18.9	20.3	21.9	23.5	25.3	27.2	29.3	31.5
	30	3.0	3.6	4.3	5.2	6.2	6.7	7.2	7.7	8.3	8.9	9.6	10.3	11.1	11.9	12.9	13.8	14.9	16.0	17.2	18.5	19.9	21.5	23.1	24.8	26.7
	40	2.4	2.9	3.5	4.2	5.1	5.5	5.9	6.3	6.8	7.3	7.9	8.5	9.1	9.8	10.5	11.3	12.2	13.1	14.1	15.2	16.4	17.6	18.9	20.4	21.9
	50	1.9	2.3	2.7	3.3	4.0	4.3	4.6	4.9	5.3	5.7	6.1	6.6	7.1	7.6	8.2	8.9	9.5	10.2	11.0	11.9	12.8	13.7	14.8	15.9	17.1
	60	1.4	1.6	2.0	2.4	2.8	3.1	3.3	3.5	3.8	4.1	4.4	4.7	5.1	5.5	5.9	6.4	6.8	7.4	7.9	8.5	9.2	9.9	10.6	11.4	12.3
	70	0.8	1.0	1.2	1.4	1.7	1.9	2.0	2.2	2.3	2.5	2.7	2.9	3.1	3.3	3.6	3.9	4.2	4.5	4.8	5.2	5.6	6.0	6.5	7.0	7.5
	80	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.9	2.0	2.1	2.3	2.5	2.7
	85.5	At this humidity the correction is zero for all air temperatures. Corrections for humidity above 85.5 are positive.																								
	90	-0.2	-0.3	-0.4	-0.4	-0.5	-0.5	-0.6	-0.6	-0.7	-0.7	-0.8	-0.8	-0.9	-1.0	-1.0	-1.1	-1.2	-1.3	-1.4	-1.5	-1.6	-1.7	-1.9	-2.0	-2.2
	100	-0.8	-0.9	-1.1	-1.3	-1.6	-1.7	-1.9	-2.0	-2.2	-2.3	-2.5	-2.7	-2.9	-3.1	-3.4	-3.6	-3.9	-4.2	-4.5	-4.8	-5.2	-5.6	-6.0	-6.5	-7.0

TABLE NO. 7. CORRECTION FOR HUMIDITY COMPILED BY USE OF McGLASHEN'S EQUATION (7).

CORRECTIONS FOR HUMIDITY IN B.T.U. WHEN OBSERVED HEATING VALUE IS 1200 B.T.U.																									
AIR T.		40	45	50	55	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
RELATIVE HUMIDITY—PERCENT	0	4.6	5.7	6.9	8.3	9.9	10.7	11.5	12.4	13.3	14.3	15.4	16.6	17.8	19.2	20.7	22.2	23.9	25.7	27.7	29.8	32.1	34.5	37.1	39.9	43.0
	10	4.2	5.1	6.1	7.3	8.8	9.4	10.2	10.9	11.8	12.7	13.6	14.7	15.8	17.0	18.3	19.6	21.1	22.7	24.5	26.3	28.3	30.5	32.8	35.3	37.9
	20	3.7	4.4	5.3	6.3	7.6	8.2	8.8	9.5	10.2	11.0	11.8	12.7	13.7	14.7	15.8	17.0	18.3	19.7	21.2	22.8	24.6	26.4	28.5	30.6	32.9
	30	3.1	3.7	4.5	5.4	6.5	7.0	7.5	8.1	8.7	9.3	10.0	10.8	11.6	12.5	13.4	14.5	15.6	16.7	18.0	19.4	20.8	22.4	24.1	26.0	27.9
	40	2.6	3.1	3.7	4.4	5.3	5.7	6.1	6.6	7.1	7.7	8.2	8.9	9.5	10.3	11.0	11.9	12.8	13.7	14.8	15.9	17.1	18.4	19.8	21.3	22.9
	50	2.0	2.4	2.9	3.5	4.2	4.5	4.8	5.2	5.6	6.0	6.4	6.9	7.4	8.0	8.6	9.3	10.0	10.7	11.6	12.4	13.4	14.4	15.5	16.7	17.9
	60	1.4	1.7	2.1	2.5	3.0	3.2	3.5	3.7	4.0	4.3	4.6	5.0	5.4	5.8	6.2	6.7	7.2	7.7	8.3	9.0	9.6	10.4	11.2	12.0	12.9
	70	0.9	1.1	1.3	1.5	1.8	2.0	2.1	2.3	2.5	2.6	2.8	3.1	3.3	3.5	3.8	4.1	4.4	4.7	5.1	5.5	5.9	6.4	6.8	7.4	7.9
	80	0.3	0.4	0.5	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.9	2.0	2.2	2.3	2.5	2.7	2.9
	85.8	At this humidity the correction is zero for all air temperatures. Corrections for humidity above 85.8 are positive.																								
	90	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.0	2.1
	100	0.8	1.0	1.1	1.4	1.6	1.8	1.9	2.1	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.7	4.0	4.3	4.6	4.9	5.3	5.7	6.1	6.6	7.1

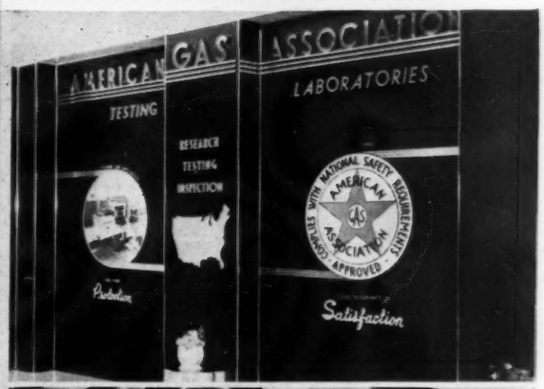
GAS

at the San Diego Exposition



Members of the Pacific Coast Gas Association will find a world of interest at the California Pacific International Exposition. We invite you . . . . won't you come?

SAN DIEGO CONSOLIDATED GAS & ELECTRIC COMPANY



So you're thinking of getting a new house?
There's nothing like GAS for
COOKING
REFRIGERATION
WATER HEATING
HOUSE HEATING
See the new ways Gas adds to comfort -saves expense
MODERNIZE YOUR HOME WITH GAS

National Advertising Copy Ready for First Releases in September

AS covered in recent issues of *GAS*, the September editions of leading women's magazines and the Saturday Evening Post will begin to carry the industry's messages released by the Committee on National Advertising. Reproduced above are two samples of the gas advertising copy which will soon be seen on the newsstands. The "Modern Gas Cookery" page at the left will appear in September McCalls, Good Housekeeping, and American Home, and in October Ladies Home Journal and Women's Home Companion. The other page will see print in the Saturday Evening Post of Sept. 12th.

Both pieces of copy are to be reproduced in four colors, and the black and white reproduction above, which is approximately 2½ times smaller than the original, does not begin to suggest the effectiveness of this fine advertising.

It will be noted above that the copy for women's magazines carries a panel which features numerous advantages of gas cookery. Also note that the Saturday Evening Post copy turns attention to four basic domestic uses of gas. It is the Committee's plan to retain this pattern throughout the series.

Natural Gas To Be Served In Philadelphia Area

NEGOTIATIONS are almost complete between Columbia Gas & Electric Corp. and United Gas Improvement Co. whereby the former will supply natural gas to gas companies serving a wide area adjoining the city of Philadelphia. Signing of the contracts will conclude arrangements begun almost four years ago.

The territory to be supplied with straight natural gas under the proposals comprises Harrisburg, Lebanon, Allentown, Bethlehem and Reading, Pa., and Wilmington, Del., and an option is to be given for the supply of natural gas for mixture with manufactured gas for the immediate suburbs of Philadelphia. About 150,000 gas consumers live in the territories to be affected.

Columbia G. & E. is part owner in three long-distance natural gas pipe lines running from the Appalachian gas fields to points near Philadelphia, so that little new construction would be required by either party to the contracts to effect connection and start deliveries of gas. The gas load requirements of the territory to be served will practically exhaust the present line capacity.

■ ■

Start Work on Silver City Gas Transmission Line

Construction of a 47-mile, 5-inch transmission line to bring natural gas to Silver City, New Mexico was started by the El Paso Natural Gas Co. late in July, according to C. C. Gragin, general manager of the company. The line, which will cost $200,000 will intersect with the trunk line of the Western Gas Co. at Gage, N. M. The gas will be supplied by the Lea County Gas Co., which is to construct a $100,000 distributing system in the city.

Between 60 and 90 days will be required for laying the pipe, and it is expected that the Silver City region will be served with gas some time in October.

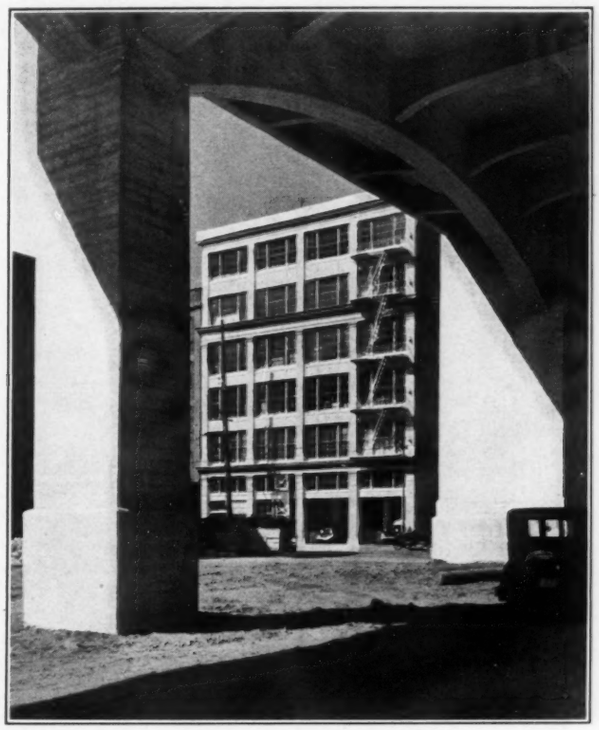
Holden Designated Manager of Natural Gas Bureau

UNDER a recent change in the operating plan of the Natural Gas Bureau, which conducts cooperative gas promotion for the three companies headquartering at Los Angeles, Harvey Holden is now acting as manager and chairman of the Bureau. Mr. Holden has been serving as a special representative of the Bureau for some time past.

Under the former plan of operation the chairmanship of the Bureau rotated each year among the three companies, but the volume of promotional activity has grown to a point where a full-time manager is necessary. An executive committee has been formed from the new business departments of the three companies, to act on Natural Gas Bureau affairs, made up of N. R. McKee (chairman) and C. H. Potter, Southern Counties Gas Co.; F. M. Banks and W. M. Jacobs, Southern California Gas Co.; Frank Weiss and Frank Moon, Los Angeles Gas and Electric Corp.

An Open Invitation To The Pacific Coast Gas Association

Delegates to the Pacific Coast Gas Association are cordially invited to inspect our new six story office and warehouse. We believe they will enthuse with us at this symbol not only of our growth but of the growth of the gas industry on the Pacific Coast. The new H. R. Basford Company building is shown below as seen through a gigantic arch of the automobile approach to the San Francisco—Oakland Bay Bridge.



The Basford Company, one of the pioneering firms in the sale and distribution of quality gas appliances, was established in 1906 and since that time has given of its time and effort in furthering the best interests of the gas industry. The Basford Company feels that its policy in handling only quality gas appliances has been responsible for its continued success and growth.

The following well-known manufacturers of gas appliances are represented in the western territory:

***For 30 years*—the Ruud Manufacturing Company, Pittsburgh, Pennsylvania, manufacturers of Ruud quality gas water heaters.**

***For 25 years*—Sprague Meter Company, Bridgeport, Connecticut, manufacturers of Sprague cast iron gas meters and regulators.**

***For 15 years*—Tappan Stove Company, Mansfield, Ohio, manufacturers of Tappan divided top gas ranges.**

***For 10 years*—Fraser Furnace Company, Stockton, California, manufacturers of Fraser Gas Heating Equipment.**

H. R. BASFORD COMPANY

Specialists in Quality Gas Appliances for over a Quarter of a Century

425 2nd Street (Next to the Bridge), San Francisco

Manufacturers group at A. G. A. Laboratories Pacific Coast Branch.

Laboratories Policies Discussed at July Meetings in California

TO take advantage of the visit made to the west coast last month by R. M. Conner, director of the American Gas Association Testing Laboratories, several meetings of gas utility men and manufacturers were held under Laboratories' auspices. On July 17 a dinner meeting took place in San Francisco at the Bellevue Hotel, where some 35 manufacturers of the Northern California area met for informal discussion of Laboratories policies. A similar meeting in Los Angeles on the evening of July 21 convened in the Pacific Coast Branch of the Laboratories, where dinner was served to a group of 79 manufacturers. At noon the same day gas company executives and engineers were entertained at a luncheon meeting in the Los Angeles Branch headquarters.

Arrangements for the western meetings were made under the direction of Dr. F. E. Vandaveer, Laboratories supervisor, now in charge of the Pacific Coast Branch.

The San Francisco meeting was presided over by Dr. Vandaveer. At the utility men's luncheon in Los Angeles A. F. Bridge of the Southern Counties Gas Co., a member of the Laboratories managing committee, acted as toastmaster, while ElRoy Payne of Payne Furnace and Supply Co. conducted the manufacturers' meeting in the evening.

The Los Angeles meetings offered opportunity for inspection of the testing and research facilities at 718 Towne Ave., where the Branch Laboratory was established by the Association six years ago.

In a brief program at the manufacturers' meeting in Los Angeles Capt. A. E. Higgins, A.G.A. field representative, and secretary of the Natural Gas Department, was the first speaker, dealing principally with the national advertising campaign which will be launched in September issues of national magazines. He also stressed the urgent need for the industry's manufacturers keeping a step ahead in the competition of today, and called attention to the service which the Laboratories have rendered from their inception in basic testing of appliances, which established a background for the program of fundamental research now included in the Laboratories' services.

Mr. Conner opened his remarks with a tribute to Dr. Vandaveer in his conduct of the Los Angeles Branch Laboratories program. Reviewing Laboratories operations he stated that to date the American Gas Association's investment in the Cleveland and Los Angeles plants represents approximately $500,000; that manufacturers have paid a total of $1,250,000 in testing fees during the 11 years of the Laboratories' operation; that the A.G.A. has expended another half million dollars in research through the Laboratories; that 26,000 appliances have undergone test and that 90 per cent of all appliances sold in the United States and Canada bear the Laboratories Seal of Approval.

Testing fees, said Mr. Conner, are set at levels to return the bare costs of the work involved, and have been consistently lowered. Indicating increasing thoroughness of the tests, and lowered testing costs, 529 tests are now run on a gas range for 10 to 15 per cent less cost than 316 tests were run several years ago.

Expressing the industry's debt of gratitude to the Laboratories committees which have guided policies and outlined the scope of the work, Mr. Conner went on to say that present plans call for rotation of committee personnel each year, with due regard to the exacting character of work done by the various requirements committees.

On the subject of the Laboratories research activities Mr. Conner reviewed the broad lines which this research has taken to date, touching upon the mixed gas investigations, pipe joint research, the industrial gas research which is still in progress, and the domestic gas appliance research program now proceeding under the direction of a committee headed by F. J. Rutledge of The United Gas Improvement Co. Conceived some five or six years ago, this appliance research program got under way late in 1935. It started on the gas range as the appliance recognized to be the bulwark of the domestic load. While indicating the vast improvement which has taken place in electric cooking equipment, Mr. Conner expressed the belief that the electric range has approached the limit of its possibilities. He paid tribute to the improved appearance and efficiency of the modern gas range, going on to say that this basic gas appliance has by no means reached its ultimate possibilities, and that any research program contributing to this end will strengthen the industry's position with regard to competition for the domestic load.

In discussing policies underlying fundamental appliance research at the Laboratories Mr. Conner made it clear that there is no intention to set up standards of construction, but that development of data which will lead to improved efficiencies and performance is plainly called for by the present competitive trend. Research activities at the Laboratories have been no burden upon manufacturers, said Mr. Conner, as financing has come through member A.G.A. utility companies for this phase of the program.

Through action of the A.G.A. executive board, the research work on gas ranges will continue for another three-month period, according to Mr. Conner.

Referring to the national advertising program he stated that all copy will carry the Laboratory Seal of Approval, and that tie-in newspaper releases will also play up the industry's laboratory program as a consumer service.

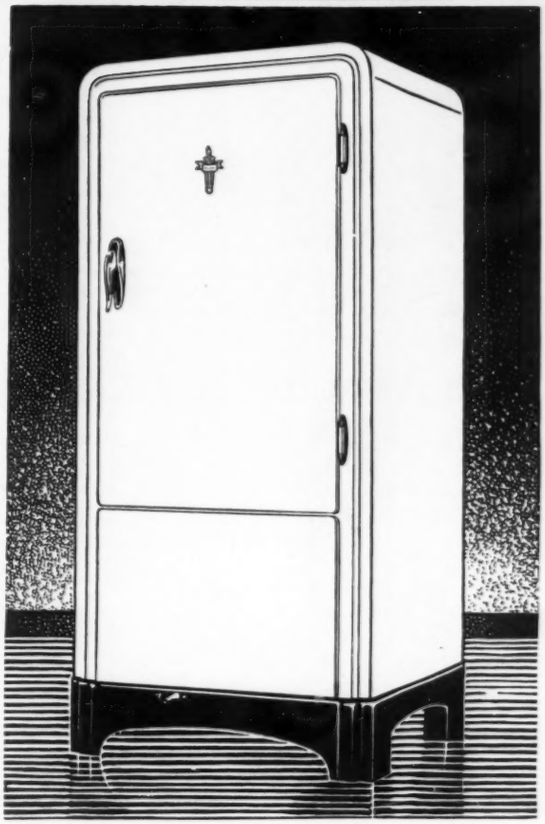
■ ■

Schmidt and Foster Advanced In Lone Star Organization

ELMER F. SCHMIDT, general superintendent of the Lone Star Gas Co., has been elected a vice-president of the company, being placed in charge of all production and transmission system activities, according to an announcement by L. B. Denning, president. Succeeding Mr. Schmidt as general superintendent is Julian L. Foster, chief engineer for the company. Mr. Foster will combine the duties of chief engineer and general superintendent.

E. F. SCHMIDT

J. L. FOSTER



Service *by the* Carload

● By carloads daily, Electrolux Gas Refrigerators arrive in Southern California to be re-checked, distributed by truck, installed.

The continued sales leadership of Electrolux in this highly competitive territory predicts a future for gas appliance merchandising far surpassing anything as yet achieved.

Los Angeles Gas and Electric Corp.

●

Southern California Gas Company

●

Southern Counties Gas Company

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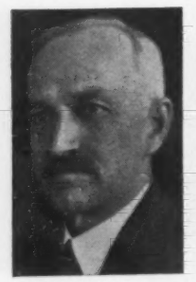


HERMAN RUSSELL
President

N. C. McGOWEN
First Vice-President

G. E. WELKER
Chr., Natural Gas Dept.

F. M. BANKS
Chr., Commercial Sec.

Committee Announces A.G.A. Nominees

THE General Nominating Committee of the American Gas Association at its meeting last month selected the following men as nominees for Association offices to be presented to the annual convention in Atlantic City, N. J., in October.

President—Herman Russell, president, Rochester Gas & Electric Corp., Rochester, N. Y.

First Vice-President—N. C. McGowen, president, United Gas Public Service Co., Houston, Texas.

Second Vice-President—Conrad N. Lauer, president, Philadelphia Gas Works Co., Philadelphia, Pa.

Treasurer—J. F. Rooney, assistant to executive vice-president, Consolidated Edison Co., New York, N. Y.

Directors—2-year terms: Charles W. Bennett, vice-president and general manager, Detroit City Gas Co., Detroit, Mich.

Henry L. Doherty, president, Henry L. Doherty & Co., New York, N. Y.

O. H. Fogg, vice-president, Consolidated Edison Co., New York, N. Y.

F. A. Newton, Commonwealth & Southern Corp., New York, N. Y.

James F. Pollard, president, Seattle Gas Co., Seattle, Wash.

William T. Rasch, president, American Gas Products Corp., New York, N. Y.

W. E. Steinwedell, president, Gas Machinery Co., Cleveland, Ohio.

John K. Swanson, vice-president and general manager, Minneapolis Gas Light Co., Minneapolis, Minn.

Percy S. Young, vice-president, Public Service Electric & Gas Co., Newark, N. J.

The following members have been nominated by section nominating committees to serve as section officers for the next Association year:

Natural Gas Department: Chairman—George E. Welker, president, United Natural Gas Co., Oil City, Pa. Vice-Chairman—Robert W. Hendee, Colorado Interstate Gas Co., Colorado Springs, Colo.

Accounting Section: Chairman—E. J. Tucker, Consumers Gas Co. of Toronto, Toronto, Ont., Canada. Vice-Chairman—Herbert E. Cliff, Public Service Electric & Gas Co., Newark, N. J.

Commercial Section: Chairman—F. M. Banks, vice-president in charge of sales, Southern California Gas Co., Los Angeles, Calif. Vice-Chairman—Hugh Cuthrell, assistant vice-president, The Brooklyn Union Gas Co., Brooklyn, N. Y.

Industrial Gas Section: Chairman—Ralph L. Manier, Syracuse Lighting Co., Syracuse, N. Y. Vice Chairman—Hale A. Clark, Detroit City Gas Co., Detroit, Mich.

Manufacturers Section: Chairman—John A. Fry, president, Detroit-Michigan Stove Co., Detroit, Mich. Vice-Chairman, Apparatus Division—Merrill N. Davis, vice-president, S. R. Dresser Manufacturing Co., Bradford, Pa. For Vice-Chairman, Appliance Division—J. Scott Fowler, president, Lovekin Water Heater Co., Philadelphia, Pa.

Publicity and Advertising Committee: Chairman—Henry Obermeyer, assistant to vice-president, Consolidated Edison Co. of New York, Inc., New York, N. Y.

Technical Section: Chairman—M. I. Mix, The Peoples Gas Light & Coke Co., Chicago, Ill. Vice-Chairman—J. V. Postles, The Philadelphia Gas Works Co., Philadelphia, Pa.

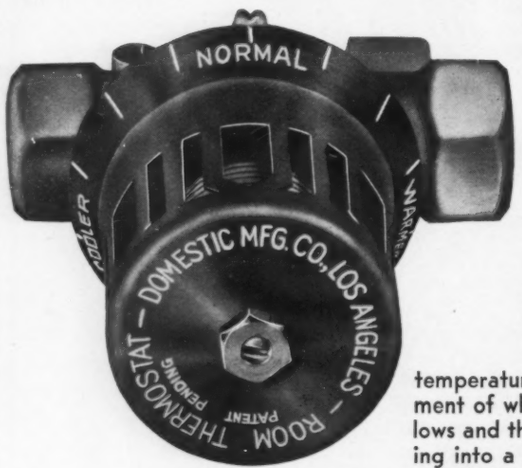
■ ■

Pennsylvania Natural Gas To Serve N. Y. Towns

THE Penn-York Natural Gas Co., subsidiary of Cities Service Co. of New York, has placed a $250,000 order with the Republic Steel Co. for 60 miles of 10¾-in. electric-welded pipe to be used in the construction of a new 140-mile pipe line which will bring natural gas from the Pennsylvania fields into western New York. An order for 80 miles of 8-in. pipe for the same line has been awarded the A. O. Smith Co. of Milwaukee. Total cost of the line is estimated at $1,500,000, and work is to start in the near future. The gas will be sold to the Republic Light, Heat & Power Co., another Cities Service subsidiary, which serves the Dunkirk and Batavia areas in New York.

The 10-in. line will be constructed from Clouderport, Pa., to Arcade, N. Y., where the line will branch into two 8-in. lines, one running to the Republic's system in Chautauqua County, the other to the Republic system in Genesee County. Other western New York towns to receive natural gas as a result of the construction are Oakfield, Attica, Fredonia, Chautauqua, Mayville, Silver Creek, and Brocton.

BOOST YOUR CONSOLE HEATER SALES With The Domestic Room Thermostat



Available in two sizes: ½-inch and ¾-inch with capacities of 50,000 and 75,000 BTU respectively.

Console heaters may readily be converted to automatic control by installing a Domestic Room Thermostat on the line ahead of the heater. Domestic Room Thermostats are a throttling type room temperature control, the thermal element of which is a genuine Sylphon bellows and the valve is of rolled brass seating into a brass casting. The whole assembly is so constructed that it may be taken apart easily for cleaning without disturbing the setting.
Already many lines of console heaters are factory equipped with Domestic Room Thermostats.

Write today for further details.

DOMESTIC MANUFACTURING COMPANY
700 East Florence Ave. Los Angeles, Calif.

PRODUCTS *of* QUALITY

BACKED BY

87 YEARS *of* SERVICE

To

California Industry

Republic Electric Weld Pipe
Walworth Valves and Fittings
Genuine Tube Turns
Dayton Couplings
Harrisburg Steel Flanges
Stainless Steel Valves and Fittings
Anaconda Copper Tubing
Westinghouse Electric Welders
Yale & Towne Pul-Lift Hoists
Goodyear Mechanical Rubber Goods
Stainless Screws, Nuts, Washers, Rivets, etc.
Morris P. Kirk Solder and Babbitt

also

TOOLS—METALS—SUPPLIES—PIPE

DUCOMMUN METALS & SUPPLY CO.

Los Angeles — San Francisco

Write for your copy of our new catalog.

Advertising Ass'n Elects Officers; Lists Utility Advertising Awards

AT the annual convention of the Public Utilities Advertising Association, held in Boston on June 30 in conjunction with the annual meeting of the Advertising Federation of America, the following officers were elected:

President—D. D. Parry, Central Hudson Gas and Electric Corp., Poughkeepsie, N. Y.

1st Vice-president—Kenneth Magers, Union Gas and Electric Co., Cincinnati, Ohio.

2nd Vice-president—Howard F. Weeks, Consolidated Edison Co. of N. Y., Inc., New York.

3rd Vice-president—E. K. Hartzell, Lake Shore Electric Railway Co., Sandusky, Ohio.

Secretary—H. W. Olcott, Jr., Philadelphia Gas Works Co., Philadelphia, Pa.

Treasurer—H. C. Cannon, Brooklyn Union Gas Co., Brooklyn, N. Y.

The following directors were elected for three year terms: Thomas H. Spain, Public Service Electric and Gas Co., Newark, N. J.; H. J. Rowe, Iowa Electric Light and Power Co., Cedar Rapids, Iowa; Will C. Grant, Lone Star Gas System, Dallas, Texas. J. C. MacDonald of the Edison Electric Illuminating Co. of Boston was elected a director to fill an unexpired term of one year.

The annual awards in the Association's Better Copy Contest were announced by Kenneth Magers, of the Union Gas and Electric Co., Cincinnati, Ohio, chairman of the Better Copy Committee.

There were seventeen classifications in the contest—four for gas companies, four for electric companies, one for gas and electric companies, two for transportation companies, and six for all public utility companies.

The gas company awards announced by Mr. Magers were as follows:

Load Building Newspaper Advertising for Gas Companies: Premier Award, The Peoples Gas Light & Coke Co. with the Public Service Co. of Northern Illinois, Chicago, Ill.; Award of Excellence, Wisconsin Public Service Corp., Oshkosh, Wis.; Award of Excellence, Syracuse Lighting Co., Syracuse, N. Y.

Public Relations Newspaper Advertising for Gas Companies: Premier Award, Consolidated Edison Co. of New York.

Merchandise Newspaper Advertising for Gas Companies: Premier Award, British Columbia Electric Railway Co., Vancouver, B. C.; Award of Excellence, New York Power and Light Corp., Niagara Hudson System.

Newspaper Advertising for Gas and Electric Companies: (Six Special Premier Awards for Copy and Idea Excellence Only) Consolidated Edison Co. of New York (Two Awards); Iowa Electric Light & Power Co., Cedar Rapids, Iowa; Philadelphia Gas Works Co., Philadelphia, Pa.; Wisconsin Public Service Corp., Oshkosh, Wis; Texas City Gas Co.

Material Designed to Promote Employee Selling: (For All Utility Companies) Premier Award, Metropolitan Edison Co.; Award of Excellence, Consolidated Edison Co. of New York; Award of Excellence, Tennessee Electric Power Co., Chattanooga, Tenn.; Award of Excellence, New Orleans Public Service Co., New Orleans, La.

Employee Newspaper or Magazine (For All Utility Companies) Premier Award, Consolidated Edison Co. of New York; Award of Excellence, Philadelphia Gas Works Co., Philadelphia, Pa.; Award of Excellence, Lone Star Gas System of Dallas; Award of Excellence, Public Service Co. of Northern Illinois, Chicago, Ill.

Bill Enclosures, Customer Publication, Envelope and Package Inserts: (For All Utility Companies) Premier Award, West Penn Power Co., Pittsburgh, Pa.; Award of Excellence, Northern States Power Co., Minneapolis, Minn.

Direct Mail Advertising: (All Utility Companies) Premier Award, Philadelphia Electric Co., Pittsburgh, Pa.; Award of Excellence, Northern States Power Co., Minneapolis, Minn.

Window or Inside Displays for Gas Companies: Premier Award, Philadelphia Gas Works Co., Philadelphia, Pa.; Award of Excellence, Consolidated Edison Co. of New York; Award of Excellence, Brooklyn Union Gas Co., Brooklyn, N. Y.

Poster Advertising: (For All Utility Companies) Premier Award, Consolidated Edison Co. of New York; Award of Excellence, British Columbia Electric Railway Co., Vancouver, B. C.; Award of Excellence, Chicago Rapid Transit Co., Chicago, Ill.; Award of Excellence, Northern States Power Co., Minneapolis, Minn.

Radio Advertising: Premier Award, Consolidated Edison Co., of New York; Award of Excellence, Philadelphia Co., Pittsburgh, Pa.; Award of Excellence, Rochester Gas and Electric Corp., Rochester, N. Y.

■ ■

Foxboro Appoints Basford

The Foxboro Co., Foxboro, Mass., manufacturer of controlling, recording and indicating instruments for temperature, pressure, humidity and the flow of fluids, has appointed the G. M. Basford Co., New York, as advertising and marketing counsel, according to an announcement made today by E. S. Lawson, advertising manager of Foxboro. The appointment will be effective August 1.

I'M THE ROBERTSHAW OVEN-HEAT-CONTROL ROBOT DIAL
You'll find me on this gas range. When you turn me to the oven temperature marked on your recipes, it's set. The baking and roasting instead of you. Use me and I'll give you many a vacation from the kitchen
SEE REVERSE SIDE FOR PRICE OF THIS MODERN GAS RANGE
"HERE LADY-

buy *this* gas range because it has Robertshaw oven-heat-control!" That, in effect, is what this lively little figure shouts when you hang him on your Robertshaw-equipped gas ranges. He ties right up with Robertshaw national advertising—running now.

He'll help you sell. He's a price tag, too. Write for a quantity.

ROBERTSHAW THERMOSTAT COMPANY
YOUNGWOOD, PA.

HYDRAUGER
MODERN HORIZONTAL BORING MACHINE
For Underground Installation of Pipe and Conduits. Avoids damage to costly pavements and saves time. Send for Bulletin.
HYDRAUGER CORPORATION, Ltd.
116 New Montgomery St.
San Francisco, Calif.

AIR CONDITIONING
Electrogas
HEATING EQUIPMENT
FURNACES BLOWERS FILTERS WASHERS
Write for attractive Dealer proposition
ELECTROGAS FURNACE & MANUFACTURING CO.
2575 Bayshore Boulevard, San Francisco

BUTANE-PROPANE NEWS

Arizona Firm Incorporated To Market Butane

Organization of the Butane Corp., an Arizona firm, which has been granted the right to distribute butane fuel, was announced last month by W. T. Joplin, vice-president of the concern and Melvin S. Jacobus, manager of the Dwight B. Heard interests, Phoenix, Arizona who founded the new corporation. Organization of the firm came as a climax of several months experimentation and research on the Heard ranch under Mr. Joplin's direction. Although the firm was founded primarily to reduce the operating expenses of the Heard organization, it is planned, if there is a demand, to offer butane to other concerns operating long-haul trucks, tractors, stationary engines, and other such equipment.

■ ■

Shamrock Oil Co. To Build Butane Polymerization Plant

Construction on a new Butane Polymerization Plant in Moore County, Texas for the Shamrock Oil & Gas Corp. will be begun immediately, the contract being awarded the Stearns-Roger Mfg. Co. of Denver. The installation, first of its type, will be built adjacent to Shamrock's McKee absorption gasoline plant. Stearns-Roger will furnish all equipment, materials, and labor under the engineering supervision of Universal Oil Products Co. of Chicago.

■ ■

Hales & Symons Constructs Butane Storage Tank

Hales & Symons, Inc., announces the recent completion of a 6,000-gallon storage tank for butane-propane fuel to serve the valley areas of Tuolumne County, Calif. A special tank delivery truck will carry the fuel to the customer from the company's plant in Sonora. C. A. Simondet has been appointed manager of the company's household appliance store while Lloyd Long will handle the installation of the butane supply tanks.

■ ■

Heart Attack Fatal To William Mankes

William Mankes, president of Miami Bottled Gas Corp., Miami, Fla., died July 13 from a sudden heart attack. Prior to organizing the Miami Bottled Gas Corp., Mr. Mankes was active in the development of bottled gas business in Sullivan County, N. Y.

It is expected that the company will be continued by his widow and by Joseph Garfield, his partner.

■ ■

Bottled Gas Men to Meet

The National Bottled Gas Association will hold its fall convention at Atlantic City between September 26-30, during the American Gas Association convention. The exact date has not yet been chosen.

Butane Trap Wagon Trailer Units

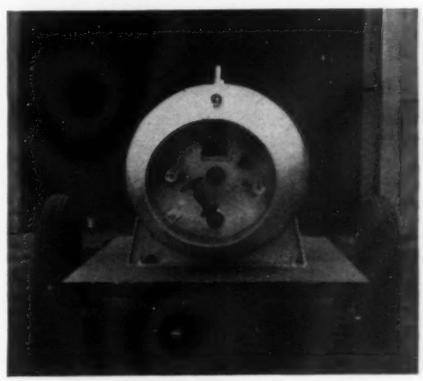
DURING the past year and a half a new means of distributing relatively small quantities of butane has been developed and has come into general use in California for servicing equipment in the field away from storage. This is a trap wagon trailer consisting of a skid tank of 330-gallon capacity at 90 per cent full, rigidly mounted on a two-wheel trailer. One company manufacturing this equipment uses channel skids welded to the tank and the skids bolted to a flat rack frame on a Ford front axle with Ford V-8 wheels. A leg is provided so that the trailer can stand alone when disconnected from the vehicle hauling it.

The tanks are built of ¼-inch flange steel in the shell and ⅜-inch in the heads. The longitudinal shell seam is electrically butt welded. The head on which the valves are mounted is electrically butt welded to the shell with a 3/16-inch by 3-inch butt strap on the inside of the seam, while the other head is electrically butt welded without reinforcement. The tank measures 36 inches O. D. by 88½ inches in length. Radius of the heads is 36 inches.

At either end of the top side of the tank there is a fuse plug with ½ inch clear discharge area. Each plug is protected by a 12 gauge steel guard. The valves and gauge, all of which are mounted on one head, are protected by a 10-inch skirt ring which is bolted to clips welded on the head, this feature making it easy to remove the skirt ring for access to the valves for repairs. The skirt ring can be equipped with a cover and locked against tampering. While the tank itself is 88½ inches long the skids are but 60 inches in length, which gives about an 8-inch track at either end for rolling the tank on timbers if it is desired to dismount it from the trailer. On a tank of this size the California Industrial Accident Commission makes the skids mandatory in order that the outlet of the safety pressure relief valve will always remain in the vapor phase when the tank is dismounted or upset. In practice the safety valve is set at 150 pounds.

The tank is filled by gravity or pressure and carries a hand pump of about 15 to 20 gallons per minute capacity and a Duprene loading hose with safety automatic shut-off nozzle for servicing equipment in the field. It is equipped with valves of rugged, heavy construction and a rotary gauge. Mounting all the fittings on the one head and protecting them by the ring skirt assures them against damage in the event the trap wagon trailer is upset on rough ground.

The trap wagon trailers weigh from about 1 to 1½ tons when loaded and can be hauled by truck or pleasure car to the location desired or can be hauled by a tractor to its scene of operations. A load will last the average tractor about one week. The trailers are advantageous in effecting similar economies in distribution for supplying such field equipment as pumping engines.



Typical butane trap wagon trailer on the Rosemary Ranch at Santa Maria, Calif., where it is used for servicing tractors.

A number of butane bulk stations have been located in California during the past two years, where trap wagon trailers, tank trucks, etc., can be loaded. Among the locations are the following towns: Brawley, Calexico, El Centro, Indio, San Diego, Huntington Beach, Los Angeles, Ventura, Bakersfield, Taft, Kettleman Hills, Fresno, Madera, Merced, Modesto, Turlock, Sonora, Lodi, Stockton, Sacramento, Marysville, Emeryville, Richmond, San Jose, Gilroy, Santa Maria, Orange Cove, Dos Pasos. Butane bulk stations have also recently been established in Salt Lake City, Utah, and Phoenix, Ariz.

■ ■

Bottled Gas Used in Road Resurfacing Work

A new device called the Heater Planer utilizes bottled gas in road resurfacing work. It is a unique combination of a tractor, motor truck, gas furnace and huge razor blade. The moving furnace, fired by bottled gas, heats the road surface to a plastic state, and a V-shaped knife following directly behind the flames slices off all bumps and ridges.

The device is the invention of Charles Blood, City Engineer of Sacramento, and is being manufactured by the Spears-Wells Machinery Co. of Oakland, Calif.

■ ■

Grant Gas Service Franchise

A franchise for the installing of a distribution system and for the natural gas service to the city of Burr Oak, Kansas, for a 20-year period was granted the Gas Service Co. at a recent meeting of the Burr Oak city council.

Just the propane cylinder valve you have been looking for . . . combines the famous Kerotest Forged Brass Diaphragm Packless Valve design with a spring safety device which automatically relieves *only* the excess pressure that may build up in a propane cylinder. Furnished with or without operating handwheel. Listed as standard by Underwriter's Laboratories.

KEROTEST MANUFACTURING COMPANY
PITTSBURGH, PA.

NATURAL GAS CUTS POWER COSTS 75%

Internal Combustion Engines Converted to the Use of Natural Gas by Barton Brown Gas-Air Mixers

REDUCE MONTHLY OPERATING COST OF $240 TO $60

1000 Installations Operating Continuously in Los Angeles District

Maximum Dependability
Minimum Servicing

ADAPTED TO ALL GASES

We Invite You to Write Us For Further Information

◆

BARTON BROWN ENGINEERING CORPORATION
1109 Santa Fe Ave.
Los Angeles

Phillips Plans Natural Gas Polymerization

THE largest expansion yet to be announced in the field of gas polymerization is represented in Phillips Petroleum Co.'s program for four new units to be located at Borger, Texas, and Kansas City, bringing their total polymerized gasoline capacity up to 4,000 barrels per day.

The three units at Borger, Texas, will have capacities of 1,000 barrels per day each, and will be used almost exclusively for the polymerization of natural gas. The process which will be used is that known as thermal polymerization, which Phillips Petroleum Co. has been active in developing and which is licensed by The Polymerization Process Corp.

The Kansas City installation will serve mainly for the polymerization of refinery gases.

■ ■

Geo. D. Roper Corp. Formulates Novel Sales Campaign

Geo. D. Roper Corp., Rockford, Ill., is offering to gas companies a novel prospectus for a "Wake Up The Kitchen" gas range sales campaign. Although the campaign stresses ranges, it is useful in the promotion of all appliances.

Symbolically representative of the campaign is the alarm clock with the hours from 9 to 12 painted gold, designating the golden morning hours as opportunity time for alert salesmen. As a reward for each sale and an inspiration for further sales, the salesmen are given a box of "Pep," the well known breakfast food. With each box is a coupon entitling the salesman to a bonus prize ranging from $1.00 to $5.00. Outlined in detail are individualistic campaign uses for the alarm clock and "Pep." The campaign is presented in a flexible manner so that each company may mold it to particular sales factors.

■ ■

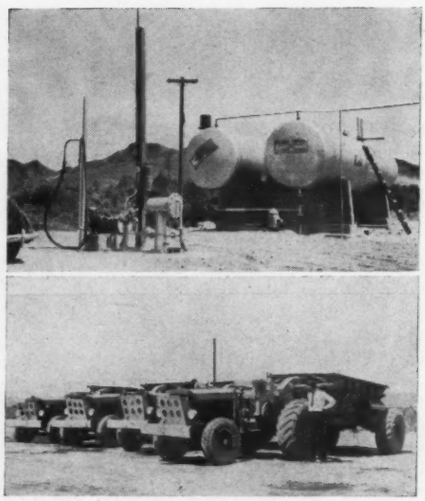
Gas Service Completes Best Range Drive Since 1930

Completing its most successful range campaign since 1930, the new business department of the Gas Service Co., Kansas City, Mo. revealed that during the month of June 1,643 ranges had been sold and installed, a decided increase over the 1,045 ranges sold and installed during the April campaign. Compared to the campaign of June 1935, the current figures show an increase of 270 sales and installations. Partially responsible for the June showing was the inauguration of a 36-month time payment plan with a 75c down payment.

■ ■

Barber Gas Burner Co. Offers New Illustrated Catalogue

Barber Gas Burner Co. of Detroit, Mich., offers to the industry its new illustrated catalog No. 37 as a guide to its line of gas conversion burners designed for any make and size of furnace or boiler. In the catalogue new models are illustrated, including a complete line of burners for gas-burning appliances outside the house-heating field. The book contains valuable engineering data on specifications, capacities, etc., and also full information on automatic controls (including all-gas controls).



UPPER: Butane storage facilities at the Imperial Dam are comprised of two 10,000-gallon tanks. In the left foreground is the Parkhill-Wade control circuit for servicing trucks and tractors. LOWER: Four of 12 bottom-dump Euclid Trac-Truks of 12 cu. yd. capacity, each of which is operated on butane at Imperial Dam.

Imperial Dam Equipment Powered by Butane

ROLLING stock engaged in dirt moving in connection with the construction of Imperial Dam is being fueled with butane. Imperial Dam, which will divert Colorado River water into the All-American Canal, is located about 15 miles from Yuma, Ariz., on the California side of the river. While work has been in progress for about the past six months, conversion of the rolling equipment to butane, using Ensign carburetors, has just been completed. In all there are 34 trucks and tractors now operating on butane, and it is planned to convert the power shovels and miscellaneous equipment to butane also as the dirt moving will not be completed for another year.

Butane is delivered to the scene of activity by rail tank car and stored in two 10,000-gallon tanks, each measuring about 84 inches in diameter by 30 feet in length. The storage tanks were built and installed by Parkhill-Wade, Inc., Los Angeles. Loading facilities for servicing the trucks and tractors consist of the Parkhill-Wade control circuit. The Geo. W. Condon Co., of Omaha, Neb., is the chief sub-contractor on dirt movement on the Imperial Dam construction.

■ ■

Temperature Relief Valve

A new temperature relief valve for gas water heaters is announced by Domestic Manufacturing Co., 700 E. Slauson Ave., Los Angeles. This unit contains a fusible metal cartridge that operates a cam which in turn actuates the valve. The valve seat is made of Duprene, a material resistant to corrosion by acids, gasoline, etc.

The Domestic temperature relief valve is reset by turning an easily accessible button and it is not necessary to replace the fusible metal cartridge after the valve has operated.

Gas Fire Control on P. C. G. A. Program

MEMBERS of the Pacific Coast Gas Association attending the 43rd convention at San Francisco will be offered an unusual demonstration of a method for handling uncontrolled gas fires. Demonstrations of this type have already been given by the Pacific Gas and Electric Co. throughout most of Northern and Central California. Wherever possible, bodies of fire chiefs were contacted, such as the Northern California Fire Chiefs' Club. In every case local and intermunicipal associations of firemen have been invited to the demonstrations.

The whole value of this enterprise lies in the recognition of the fact that firemen generally insist upon extinguishing uncontrolled gas fires and do not realize the danger of explosion involved in blowing out the gas flames. The demonstration, originally conceived by J. E. C. Currens and developed with the assistance of A. E. Englebright and S. C. Dickinson of the Pacific Gas and Electric Co., will be reenacted for the convention with the thought that the resulting discussion may suggest still greater improvements in this educational enterprise.

The demonstration consists of two parts: (1) A laboratory test and lecture designed to upset certain popular preconceived ideas concerning burning fluids and gases, and (2) a field presentation pointing to the fact that it is usually wiser to allow an uncontrolled gas fire to burn within or adjacent to a structure than to blow it out, the main effort being to devise methods for keeping the building from burning during the interim between the discovery of the fire and the shut-off of the gas. When this method is pursued there will not be as many front page news articles entitled "Disastrous Gas Explosion."

■ ■

Lone Star Appeals Decision In Anti-Dilution Case

The decision of Federal Judge William H. Atwell in the Lone Star Gas Co.'s Fort Worth stabilization case has been appealed to the U. S. Circuit Court of Appeals at New Orleans, according to officials of the Lone Star Co., which was denied an injunction to restrain Fort Worth from enforcing its anti-stabilization ordinance.

The court's opinion stated that the city council was within its legal authority in passing the ordinance, but stated that the question of whether the ordinance was just or reasonable was not a matter for the court to decide. The city will make no move to enforce the law immediately, according to City Manager George D. Fairtrace.

■ ■

Forster Co. Markets Burners On National Scale

Marketing of its gas burners on a national scale has recently been started by the Forster Mfg. Co., Ltd., Berkeley, Calif. This company is producing over 70 different types of patented burners and torches for use with natural, manufactured and liquefied gases. Burner head combustion and numerous patented features distinguish the units.

At present, eight representatives are distributing Forster burners, and the company is seeking responsible dealers and agents.

Uniformity that includes Every Detail

There is uniformity in Hackney liquefied petroleum gas cylinders. From the selection of raw materials down to the finishing of the smallest detail there is a uniform excellence of quality.

Every Hackney cylinder assures proper location of valves, accurate capacity, uniform wall thickness and smoothness, fine appearance and light weight with great strength.

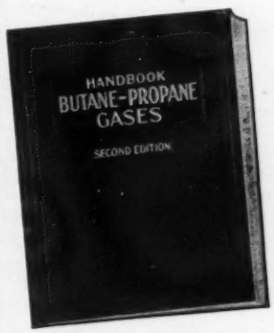
Because Hackney cylinders are uniform in every way, to provide long economical service and ease of handling, they have won complete leadership of the field.

Hackney MILWAUKEE

PRESSED STEEL TANK COMPANY

Rm. 1185—208 S. La Salle St. Bldg., Chicago, Ill.; 6633 Greenfield Ave., Milwaukee, Wis.; 666 Roosevelt Bldg., Los Angeles; 1363 Vanderbilt Concourse Bldg., New York

Containers for Gases, Liquids and Solids



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Eighth consecutive year of regional cooperative advertising, Pacific Coast Gas Association

MORE THAN 260 GAS INSTALLATIONS AND TESTIMONIALS PUBLICIZED

Co-op. Advertising Presents Enormous Volume of Convincing Evidence That Gas is the Preferred, Modern Fuel

In advertising there are two types of "Testimonials"—the insincere, paid statements of pseudo-celebrities; and conservative, thoughtfully considered facts voluntarily stated by hard-headed business men.

Believing that testimonials of the latter kind comprise the most effective and convincing advertising—particularly for trade journals — the P. C. G. A. Co-op. Advertising Committee has featured actual gas installations throughout its regional campaign.

More than 260 important installations, industrial and commercial, have been publicized through Pacific Coast trade journals during 84 months' continuous advertising.
These include leading concerns in all lines of business and industry, using gas for every conceivable heat requirement.

In the restaurant field, such famous eating places as the States Restaurant in San Francisco; Palm Springs' Desert Inn; Caesar in San Diego; Seattle's "Coon Chicken" chain and many others have been featured.

Bakeries whose gas-fired ovens have been illustrated and described represent a "Blue Book" of the industry, including Langendorf, Los Angeles; New England Pie Co., Oakland; Hol Wheat Wafers, Spokane; Hansen's, Seattle, etc.

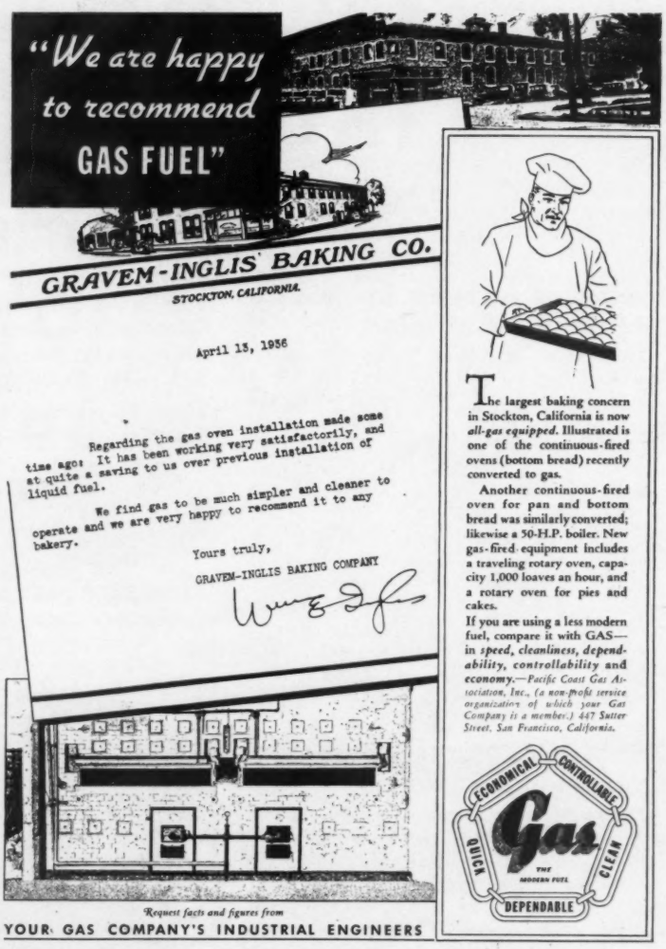
In the steel and allied industries, many big names have appeared on the "honor roll" of gas fuel advocates, such as: Columbia Steel, Santa Fe Railroad, Boeing Aircraft, Judson Manufacturing Co., Pacific Coast Steel, General Cable, etc. And so through a long list of important industrial and commercial consumers—including laundries, hotels, dairies and varied factories.

Another division of the campaign has featured the work of leading Pacific Coast architects and builders who specify gas-fired equipment.

Still another group receiving monthly publicity comprises important appliance dealers—furniture and specialty stores, and plumbing and heating contractors—who, through modern merchandising methods and cooperation with the gas companies, have set an example for others in their respective lines.

All the above in addition to DOMESTIC CONSUMER advertising in regional magazines which, like the trade journal copy, is "keyed" to Pacific Coast seasonal and sales conditions, and appears the year around.

See the Exhibit of this Regional Advertising at the San Francisco Convention


"We are happy to recommend GAS FUEL"
GRAVEM-INGLIS BAKING CO.
STOCKTON, CALIFORNIA.
April 13, 1936
Regarding the gas oven installation made some time ago: It has been working very satisfactorily, and at quite a saving to us over previous installation of liquid fuel.
We find gas to be much simpler and cleaner to operate and we are very happy to recommend it to any bakery.
Yours truly,
GRAVEM-INGLIS BAKING COMPANY
The largest baking concern in Stockton, California is now all-gas equipped. Illustrated is one of the continuous-fired ovens (bottom bread) recently converted to gas.
Another continuous-fired oven for pan and bottom bread was similarly converted; likewise a 50-H.P. boiler. New gas-fired equipment includes a traveling rotary oven, capacity 1,000 loaves an hour, and a rotary oven for pies and cakes.
If you are using a less modern fuel, compare it with GAS—in speed, cleanliness, dependability, controllability and economy.—Pacific Coast Gas Association, Inc., (a non-profit service organization of which your Gas Company is a member.) 447 Sutter Street, San Francisco, California.
ECONOMICAL
CONTROLLABLE
QUICK
CLEAN
DEPENDABLE
Gas
THE MODERN FUEL
Request facts and figures from
YOUR GAS COMPANY'S INDUSTRIAL ENGINEERS

TYPICAL TESTIMONIAL by a leading Pacific Coast industrial gas consumer. This advertisement appeared recently in "WESTERN BAKER."

Banquet group at Canadian-Pacific Coast joint meetings—Hotel Vancouver, July 9.

Canadian-West Coast Session at Vancouver

WHEN the Canadian Gas Association determined to combine its twenty-ninth annual convention with the annual P.C.G.A. Northwest Conference, the July 8-10 joint meeting was something in the nature of an experiment. The Canadian group had to draw its membership in large part from Eastern Canada; the P.C.G.A. had to bring its delegates to the extreme North of its territory, to Vancouver, B.C.

That the experiment succeeded most admirably is evident in the large number of gas men on hand to enjoy the hospitality of C.G.A. President John Keillor and his associates of the British Columbia Electric Power & Gas Co. A record for Canadian conventions was set by the 250 attendance, 104 of this number coming from the Pacific Coast, including about 50 from California.

Bringing the convention to Vancouver was in tribute to John Keillor who achieved the C.G.A. presidency after many years of active work in its service. Mr. Keillor was instrumental in organizing the association in 1907, and served as its secretary-treasurer until 1917.

By action at the Vancouver meeting the Canadian Gas Association ratified the amendment to its constitution which placed all types of gas service, including natural gas, on the same active membership basis, and incorporated a complete revision of membership fees.

Annual elections of the Canadian group brought into office the following:

President: W. H. Munro, general manager, Ottawa Gas Co.

1st Vice-President: Edward J. Tucker, assistant general manager and secretary, Consumers Gas Co., Toronto.

2nd Vice-President: T. P. Pinckard, vice-president and general manager, United Gas and Fuel Co. of Hamilton, Ltd.

Secretary-Treasurer: G. W. Allen, Toronto.

Elected to serve on the executive committee were the following: J. M. H. Young, London, Ont.; Hugh McNair, Winnipeg, Man.; J. C. Dawson, Quebec, Que.; V. S. McIntyre, Kitchener, Ont.; J. J. Humphreys, Montreal, Que.; Julian Garrett, Edmonton, Alta.; J. B. McNary, Hamilton, Ont.; H. B. Fairweather, St. John, N. B.; D. G. Munroe, Montreal, Que.; John Keillor, Vancouver, B. C.

On the nominating committee were J. B. McNary (chairman), Harry S. Williams, A. McKenzie, P. D. Mellon, and D. MacIntyre.

By unanimous agreement the C.G.A. accepted President-Elect Munro's invitation to hold the 1937 convention in Ottawa. Dates probably will fall in the month of June.

In his presidential address, Mr. Keillor introduced the subject of changing heating standards in Canada to the therm basis rather than the volumetric. His recommendation that a special committee be appointed to investigate the subject and to consider advisability of approaching the Dominion Government was embodied in a formal convention resolution.

Pacific Coast Gas Association President H. M. Crawford was on hand to head the P.C.G.A. delegation. Mr. Crawford also contributed valuably to the program, dealing with the need for capitalizing on unsold markets for gas in the low income brackets. P.C.G.A. Vice-President James F. Pollard was another program headliner, presenting the American Gas Association's advertising program to the convention in a most interesting way.

A luncheon for P.C.G.A. delegates took place on July 10, with President Crawford as toastmaster.

Vancouver's superb environment and the unusual lengths to which the B. C. Electric hosts went in providing entertainment made the social side of the convention an experience long to be remembered. Most notable of all was the cruise on scenic Howe Sound, on the Canadian Pacific S.S. Kathleen, on the afternoon and evening of July 8. Dinner was served on board, with B. C. Electric's gas band and a dance orchestra on hand to entertain.

Trips of inspection were arranged to B. C. Electric's all-gas home at 39th and Highbury in Vancouver. Another inspection trip took the visiting gas men through the company's Carrall Street gas plant, one of the most modern chamber oven installations in the world. On Thursday evening came the convention banquet, pictured above.

On page 18 will be found a number of *G A S Camera* views which feature Vancouver convention personalities and locale.

CURB METER INSTALLATIONS

Investigate the practical advantages of ART CONCRETE SECTIONAL METER BOXES now extensively used by leading gas distributors.

Complete protection for curb meters. Furnished in combinations suitable for single and multiple set-ups, low and high pressure. Length of box readily extended without removing initial installation. Knockouts for pipe connections. Reinforced concrete covers and lids standard—cast iron optional.

Also round curb valve boxes in different sizes, fitted with break-away grooves for varying depths and break-away pipe slots.

ART CONCRETE WORKS

Originators and Manufacturers

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2400 Adeline St., Oakland, Calif.
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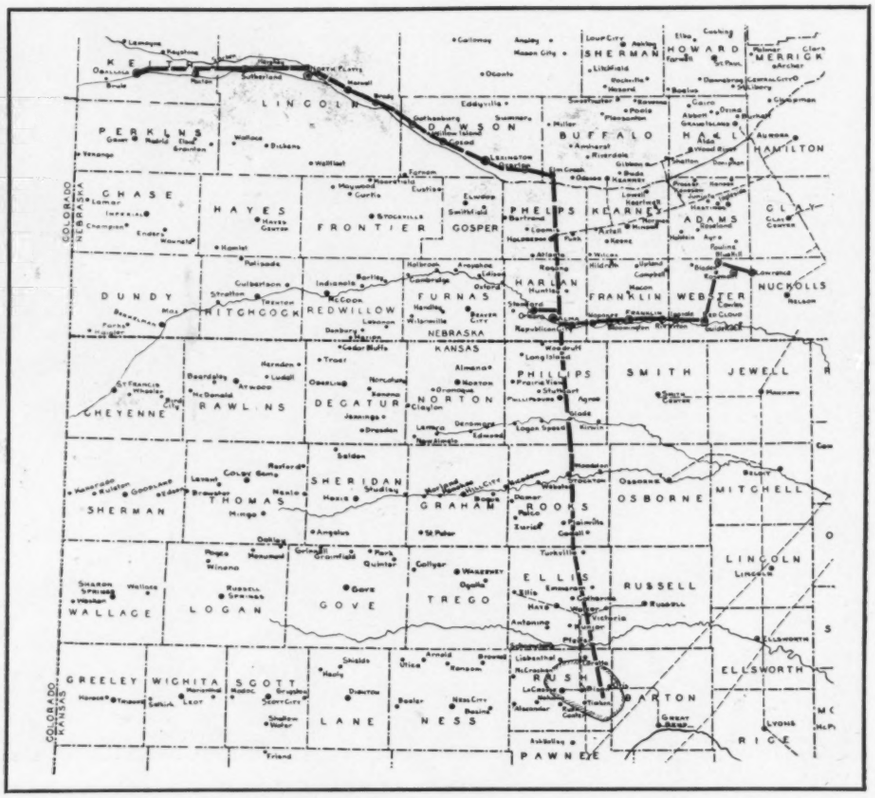

Kansas Pipe Line and Gas Co. system, owned and under construction, shown in heavy broken line; light lines indicate natural gas systems owned by other companies. Circled dots indicate towns served or to be served at wholesale by Kansas Pipe Line and Gas in 1936.

BETTER PURIFICATION
with
CONNELLY
PURIFYING MATERIALS

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Iron Oxide Ore — Commercially Dry — High in Ferric Oxide—Hydrated and Properly Alkalinized—Ready for Mixing—Bulk or Bagged.

"Iron Sponge"—Connelly Trade Name—Ready Mixed; Prepared from Connelly Oxide Ore and best available fillers; Connelly Special Fillers increase life of Sponge.

Connelly Materials are prepared for Maximum Activity and Capacity; Investigate before you invest; Buy on experience and specifications.

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Write for Bulletins

Caloroptic BTU Indicator; H_2S Testers; Regulators for District, Service, and Appliance; Back Pressure Valves; U-Gauges.

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Connelly Iron Sponge & Governor Company
Chicago, Ill. 3154 South California Ave.
Elizabeth, N. J. 200 South Second Ave.
N. E. Agent—Theo. H. Piser, Wellesley Hills, Mass.

Work on Kansas Pipe Line and Gas Co. 350-mile Project Nears Completion

AT the present rate of construction 350 miles of The Kansas Pipe Line and Gas Co. pipe line project, representing the principal portion of the system planned by the organization, will be brought to completion by the middle of August.

Construction of the system covering an extensive territory in Central and Western Kansas and Western Nebraska, was launched when a lease-arrangement terminated between The Kansas Pipe Line and Gas Co., and several other interests in the Stanolind line that extends from Welch, Wyoming, across Nebraska and a part of Kansas to Freeman, Mo. Originally an oil line, the system was reconditioned for gas in 1931. The Kansas Pipe Line and Gas Co. has leased a 300-mile stretch of the line between Keystone, Neb., and Freeman, Mo.

The current development parallels the Stanolind line from Ogallala, Neb., to Elm Creek, Neb., and then drops due South to Rush Co., Kansas, gas fields. Gas is supplied to Ogallala, North Platte, Maxwell, Brady, Gothenburg, Gozad, Lexington, Overton and Elm Creek on the East-West portion, these having been originally supplied from the Stanolind line. Paxton, Sutherland and Hershey have been added to the system as new gas towns.

South from Elm Creek, gas is being supplied at Alma, Stuttgart, Stockton and Plainville. A lateral line takes-off at Alma, due east to Red Cloud where it connects with a line extending northeast to Blue Hill. A line has been constructed southeast from this point to Lawrence. Towns being supplied from this line are Republican City, Napanee, Bloomington, Franklin, Riverton, Inavale, Red Cloud, Blue Hill and Lawrence.

Another lateral line extends west from Alma to Cambridge with immediate plans calling for an extension of this line to Beaver City, Holbrook, Oxford, Arapahoe, and Orleans. Other franchises are pending in north central Kansas and a development is contemplated to serve the Loup River Valley in Nebraska.

Reese McGhee Contracting Co. had charge of constructing the unit of the line from Ogallala to Holdredge, Neb., a distance of 150 miles. Construction commenced on May 1st and terminated July 10 when the line was tied-in to the Holdredge-Rush County 140-mile unit being constructed by Williams Brothers Contracting Company. The main line is of 8- and 6-inch pipe.

The line from Alma to Red Cloud, on which construction began on July 10 is 4-inch in diameter. Reese McGhee has constructed this unit of 45 miles which is being completed August 1, and will also construct the 6-, 4- and 2-inch line extending west from Alma to Cambridge, Beaver City, Oxford,

Arapahoe, etc. Approximately 70 miles of pipe will go into the line west of Alma.

The Blue Hill to Lawrence line, 10 miles in length and 2-inch in diameter was reconditioned from inter-connections on the Stanolind line. It was salvaged and relaid by M. E. White.

Two compressor stations are being constructed, one at Stockton, Kans., and another at Elm Creek, Nebr. Three 150-h.p. Worthington Units will go into each station.

The company contemplates looping its line at the Southern end in Ellis County at some future date in order to provide larger capacities for drilling and pumping gas requirements in this very active drilling area. This gas will be sold to Producers Gas Co. for distribution in Ellis and Rush Counties.

The Kansas Pipe Line and Gas Co. sells chiefly at wholesale, with Nebraska Gas Fuel Co., North Western Public Service Co., Southern Nebraska Natural Gas Co., and the Producers Gas Co. as distributors.

For the most part the line has extended through level country with no unusual construction problems involved. The soil conditions in the Platte River Valley required that pipe in this area be protected with No-Ox-Id.

Crane valves control the line which is being tested for 700 lbs. pressure. It will be operated at pressures required up to this maximum. One-hundred per cent of the theoretical capacity of the line will also be attained, according to officials of the company. The line is Dresser-coupled with the pipe being supplied by Republic Steel mills.

With the line traversing a very important farming area in both Nebraska and Kansas, gas is expected to be sold in important volumes to companies allied with farm products. Such an installation is represented by the Denver Alfalfa Milling and Products Co., which has installed two gas-fired units for dehydration of Alfalfa.

L. E. Fischer is president of The Kansas Pipe Line and Gas Co.; D. H. Holmes, vice-president, secretary and treasurer; George Burton, vice-president and counsel. C. R. Robinson of the Inland Steel Co. has recently been elected a director of the company.

P. G. & E. Sells 3,159 Water Heaters

SHOWING a 59 per cent increase in sales over last year, the May automatic water heater campaign of the Pacific Gas and Electric Co. resulted in 3,159 units sold as compared with the 1935 figure of 1,990, according to figures just released by H. M. Crawford, general sales manager of the company.

The campaign which aimed to replace non-automatic water heaters and water backs, featured a $12.50 trade-in allowance on sales of all new A.G.A.-approved automatic heaters retailing at $50.00 or more not installed. Survey records of the company indicated which homes had water heaters eligible for this trade-in allowance, and a broadside on the special offer was sent to each one. Limiting the trade-in allowance to higher-priced heaters had the effect of raising the dealers' average considerably above the cheaper competitive heaters dominating the market, giving them a good slice of "plus" business. Of the $12.50 allowed, $7.50 was absorbed by the dealer, $3.00 by the utility, and $2.00 by the manufacturer of the heater.

To automatic water heater advertising throughout the campaign the Pacific Gas and Electric Co. devoted space in 196 newspapers throughout its territory, displays on its 305 billboards, bill stickers on 500,000 bills, broadsides to customers, and floor and window displays in all of its 56 offices. In addition the company offered to pay one-third of all dealer advertising featuring automatic water heaters retailing at $50.00 or more.

The provisions of the campaign required that the $12.50 allowance be made only where non-automatic water heaters or water backs were replaced.

■ ■

R. B. Brown Honored

Conferred upon R. B. Brown, president of the Milwaukee Gas Light Co., Milwaukee, Wis. was the honorary degree of Doctor of Science by the University of Wisconsin at the graduation exercises in Madison last June.

A New Goal In Efficient & Economical Cooling

The design and construction of the Fluor Aerator Type Cooling Towers have been governed generally by the condition of full cooling efficiency under all weather and operating conditions and specifically by positive elimination of wind-blown spray, measurable reduction of water make-up requirements due to wind losses, the utilization of minmum ground space and the savings and economies attendant to these factors.

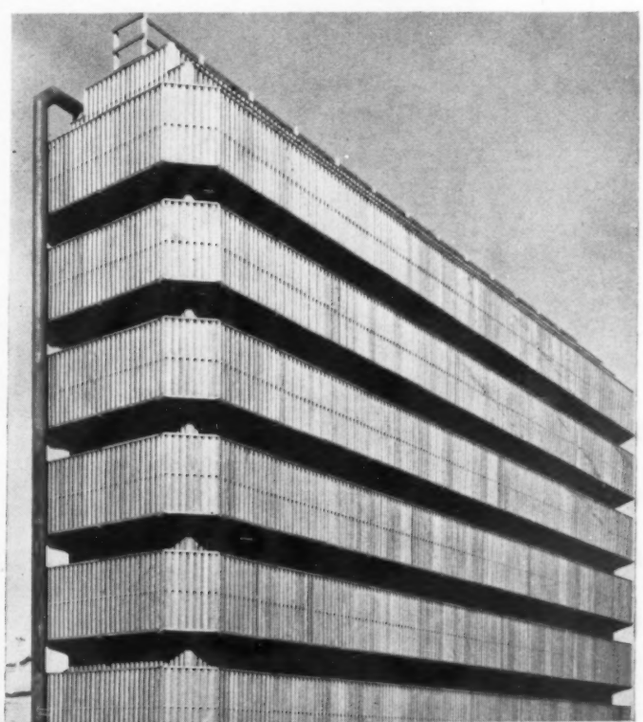
Proof that the Aerator Type Cooling Tower has achieved a new goal in efficient and economical cooling is offered in the fact that more of these towers are being purchased today than all other types of atmospheric towers combined.

Write for new descriptive Bulletin, T-236.

THE FLUOR CORPORATION, LTD.

909 East 59th Street, Los Angeles, California

30 Church St., New York City, N. Y.; 909 McCormick Bldg., Chicago, Illinois; 1406 Esperson Bldg., Houston, Texas; 703 Fairfax Bldg., Kansas City, Mo.; 719 McBirney Bldg., Tulsa, Oklahoma



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FLUOR AERATOR TYPE COOLING TOWERS

Make the FAIRMONT HOTEL
Your Headquarters Too!

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•
CONVENTION HEADQUARTERS
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Make Reservations Early!

Delegates to the Convention, the Fairmont welcomes you! And extends a cordial invitation to make the Fairmont your home and YOUR headquarters.

Located on the crest of aristocratic Nob Hill, and affording one of the really-superb marine views of the world, the Fairmont offers unmatched luxury at nominal cost. Sparkling gaiety in the unique Circus Cocktail Lounge . . . spacious rooms . . . modern swimming pool . . . garage on premises . . . three minutes to shops and theatres. Everything to make your visit a delight to be remembered. Cuisine that is nationally famous.

Rates from $3.50.

San Francisco's Most Distinctive Hotel . . . George D. Smith, Mgr.

Reservations can be made direct or, in Southern California through . . .

Glen W. Fawcett
510 West 6th St.
Los Angeles, Cal.

MUELLER GAS DISTRIBUTION EQUIPMENT

The time-tested Mueller line includes Mueller Evenflow Service Regulators, Gas Stops, Service Stops, Stove Stops, Drilling and Tapping Machines, service boxes, meter trims and similar equipment. Write for description and prices.

MUELLER CO., Los Angeles, Calif.

Factories: Decatur, Ill.; Chattanooga, Tenn.; Los Angeles, Calif.; Sarnia, Ont.
Branches: New York and San Francisco

COL. E. S. DICKEY

E. S. Dickey of American Meter Co. Passes

COL. E. S. DICKEY, manager of Maryland Meter Works and Executive Representative of the American Meter Co., died suddenly in Baltimore last June 20th. He is survived by his widow, Mrs. Edmund S. Dickey and a daughter, Mrs. Arline D. Brooks.

Col. Dickey was born April 18, 1873, entering the meter business in 1889 as an apprentice with Dickey, Tansley & Co. This concern operated Maryland Meter Works which became part of American Meter Co. in 1876. Between 1891 and 1896, Col. Dickey served with the Pennsylvania Railroad, and The Metropolitan Life Insurance Co., returning to the Maryland Meter Works in 1896, where he was appointed Works Manager in 1899, General Manager in 1911 and Executive Representative of American Meter Co. in 1935. During his activities as Works Manager, Col. Dickey, developed in cooperation with gas company engineers and his own associates, the B-Type meter with increased capacity, conservative slow speed, improved construction as compared to the 5-Light size manufactured in 1906. The development of the B-Type meter was continued in subsequent years to include all of the larger sizes of this type as now manufactured. In 1916 and 1917 in collaboration with the late George A. Lane, Superintendent of Meters, Peoples Gas Light & Coke Co., Chicago, he developed the double-diaphragm, large capacity meters now manufactured and known as the C Type Meters.

Col. Dickey travelled extensively throughout the country during the past 35 years making many friends and acquaintances among the associated appliance company officials and the operating officials of the various gas companies. He became a member of the old American Gas Light Association at the Denver Meeting, in 1900. He remanied an active member of that association and its successor the American Gas Institute; and also of the National Commercial Gas Association. Upon the merger of these associations in 1919, he served as a member of the first Board of Directors of the new American Gas Association under the direction of its first President, the Honorable George B. Cortelyou. He was chairman of the Manufactur-

ers' Section, American Gas Association, in 1930-1931.

Col. Dickey was also active in business and politics of Baltimore. Due to his interest in the Maryland National Guard, he was appointed Colonel on the Staff of the Governor of Maryland, in April, 1916. Col. Dickey was the brother of the late C. H. Dickey, president of American Meter Co. His passing is deeply mourned by his associates in the American Meter Co. and a host of friends throughout the Gas Industry.

■ ■

F. H. Brooks Elected Northern Natural President

FRANK H. BROOKS

Frank H. Brooks, former president of the Iowa-Nebraska Light and Power Co., was elected president of the Northern Natural Gas Co., headquartering in Omaha, at the July meeting of the board of directors in St. Louis. Mr. Brooks left the Iowa-Nebraska utility five years ago, and has since served Northern Natural as vice-president and general manager. He succeeds L. E. Fischer, who resigned as president a year ago.

Throughout the greater part of his business life, Mr. Brooks has been connected with utilities in the middle west. Last year he served as president of the Mid-West Gas Association.

Other Northern Natural promotions include Hiram Carlson, former chief engineer, who was made superintendent of operations, and John Merriam who was appointed assistant secretary and assistant to the president.

■ ■

So. Calif. Meter Ass'n Holds First Meeting of Year

THE Southern California Meter Association held its first meeting of its new fiscal year on July 23rd at the Van Matre Inn, Huntington Park, Calif., with Guy Corfield, research engineer of the Los Angeles Gas & Electric Corp., new S.C.M.A. president, in the chair. Thirty members attended the meeting.

A program arranged by D. M. Hill of the Foxboro Co., retiring program chairman, presented J. J. Delaney, general sales manager of the Reliance Regulator Corp., in a paper on "Pressure Regulation," and D. R. Hiskey, chief chemist of the Southern California Gas Co., in an illustrated lecture on "Corrosion Mitigation on the West Coast." In connection with Mr. Hiskey's lecture a motion picture in color showing various phases of pipe line corrosion and methods of treatment was offered through the courtesy of the Southern California Gas Co.

A joint meeting of the Association's retiring and incoming boards of directors was held August 5 at the Van Matre Inn. Plans for the coming year were discussed and arrangements for the program to be given at the August 28 meeting were completed.

OVENS AND GUNS

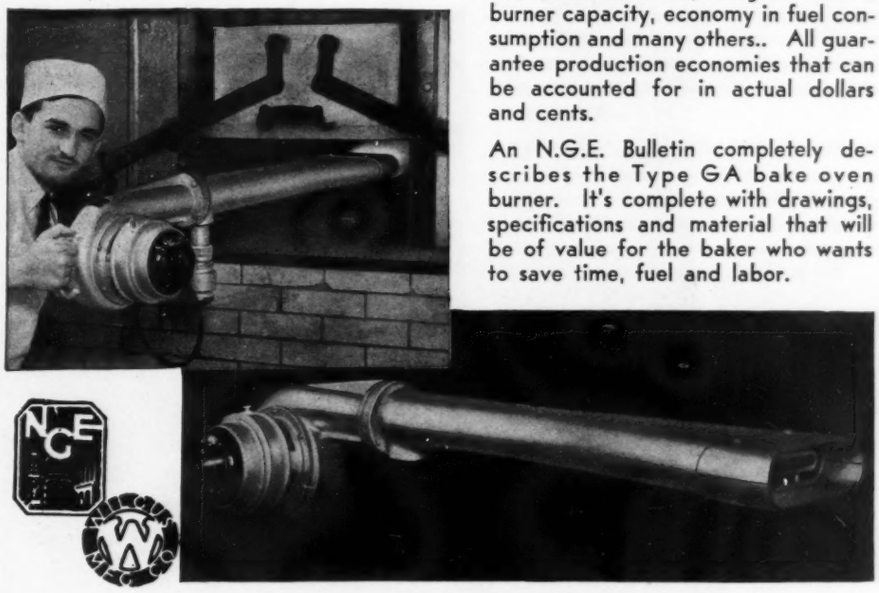
The N.G.E. Type GA Burner Solves Direct-Fired Bake Oven Problems

The N.G.E. Type GA Bake Oven Burner will effect measurable economies for bakers in their all-important items—space, fuel, time and labor. Developed by engineers thoroughly familiar with bake oven design and operation, the N.G.E. Type GA is particularly suited for installation in the direct-fired, inside furnace or "Dutch" oven.

Note from illustration below how burner is easily swung into firing position,—how it may be pointed to any cold corner of the oven just like a gun,—how proper heat can be "shot in" to get perfect baking results. Adjustments are simple,—and a dial valve permits exact settings.

Here are other items of its exclusive design: uniform heat distribution, perfect combustion, large reserve burner capacity, economy in fuel consumption and many others.. All guarantee production economies that can be accounted for in actual dollars and cents.

An N.G.E. Bulletin completely describes the Type GA bake oven burner. It's complete with drawings, specifications and material that will be of value for the baker who wants to save time, fuel and labor.



THE N. G. E. TYPE GA BAKE OVEN BURNER

NATURAL GAS EQUIPMENT INC.

1123 Harrison St. San Francisco, Calif. | 1024 Truxtun Ave. Bakersfield, Calif. | Petroleum Securities Bldg. Los Angeles, Calif.

LOOK TO THE PIONEERS FOR CONTINUED LEADERSHIP

PORCELAIN ENAMEL INSTITUTE, INC.
612 NORTH MICHIGAN AVENUE • CHICAGO

Please send me, absolutely free, a copy of your new, easy-reading, profusely illustrated sales manual on Porcelain Enamel.

Name_____

Firm_____

Address_____

Minneapolis-Honeywell Expands

WITH the completion of the wing shown at the left of the picture above, the Minneapolis-Honeywell Regulator Co. has enlarged its plant and main office at Minneapolis, providing nearly 50 per cent more floor space than has been hitherto available. On top of the new wing is an experimental frame bungalow, built to usual specifications and insulated in the normal manner. Provision has been made for heating by warm air, steam, or hot water, and the house is equipped with the necessary duct work for air conditioning.

Directly beneath the house is the test department of the Engineering Division in which are located boiler, furnace, and air-conditioning equipment used in experimentation and research on any desired method of heating or air conditioning. The company's research facilities are further enhanced by the three complete sets of air-conditioning equipment installed for the comfort of employees working on the fifth and sixth floors of the building.

■ ■

So. Calif. Gas Buys Site

The Southern California Gas Co. has purchased the corner lot immediately north of the Los Angeles Gas & Electric Corp.'s Flower street office. The company plans eventually to build an office structure on the property, but no definite building program has been announced to date.

REFRACTORIES
GENERAL CERAMICS COMPANY
• REFRACTORIES •
For Conversion Burners, Circulating Heaters, etc.
Because they are uniformly accurate, strong, and dependable in every way, General Ceramics Refractories are used by most of the leading manufacturers of gas heating appliances. • Our engineers will gladly cooperate with you.
General Ceramics Company, 30 Rockefeller Plaza, New York

The Goodman Stopper
The Reliable Shut-off for Street Mains
Equipped with Improved Patented Locking Sleeve, which locks both handles to the pipe. Stopper cannot slip. Gas cannot pass.
Safety Gas Main Stopper Co.
523 Atlantic Avenue, Brooklyn, N. Y.
Pac. Coast Rep.: C. B. Babcock Co.
135 Bluxome Street
San Francisco, California

Gas Marches On!

(Continued from Page 13)

a skit entitled, "The Streets of San Francisco," which promises to be very entertaining. Among other interesting events will be a boat trip around the San Francisco Bay to permit the gas men and their families to view the construction work on the two huge bridges now rapidly nearing completion.

Preprinted in this issue of *GAS* are a number of the papers and reports prepared for this year's convention. The Association points with pardonable pride to the high character of its program features, this year and every year, and the contents of this issue give a good foretaste of what the coming convention has in store.

■ ■

Pittsburgh Equitable Appoints Dillman to Sales Post

F. N. DILLMAN

The Pittsburgh Equitable Meter Co., Pittsburgh, Pa., announces the appointment of F. N. Dillman as sales engineer.

After graduation from Kansas State University in 1924, Mr. Dillman joined the Kansas State Highway Department as a civil engineer. Since then he has been engaged in various types of sales work. For the two years prior to joining the meter company, he was with the Continental Oil Co. in the sales division.

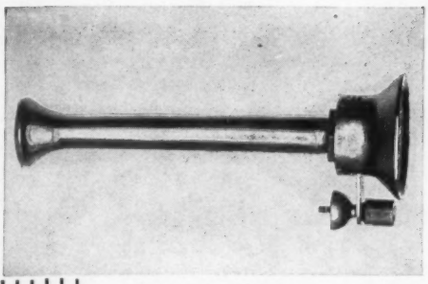
Mr. Dillman will work out of the Tulsa, Okla. office and will be in charge of EMCO-McGaughty Integrator Sales and Service under the supervision of J. L. Cottrell.

■ ■

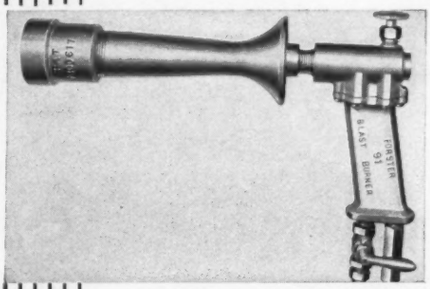
F. K. Berry, A-B Stove Co. Co-founder, Is Dead

FRANK K. BERRY, 66 years of age, former president and general manager of the A-B Stove Co., of which he was co-founder, succumbed to a heart attack in Battle Creek, Mich., on June 27. At the time of his death he was president of the Marshall Furnace Co. in Battle Creek.

Mr. Berry's entire business career has been spent in the stove and heating fields. His first positions while still in his teens were with the Harper-McIntyre Co. and McCarroll & Sons Co. in Ottumwa. In 1900 he was division manager of the National Stove Co. In 1909 together with the late J. A. Alexander and Paul C. DeVol, Mr. Berry founded the A-B Stove Co. in Battle Creek, serving as president until his retirement a year ago. Throughout the past 25 years Mr. Berry has been prominently identified with the industrial and civic life of that community.



Straight shot Burner No. 151 with Pilot. Gives spread and straight flame simultaneously.



Blast Burner No. 91. Suitable for large variety of high temperature work up to 3000° F., including preheating, annealing, etc.

Ask for PROOF *of*
HIGHER BURNER EFFICIENCY
Whatever your Heating Needs

INVESTIGATE the Forster line of over 70 different types of patented gas burners and torches, used extensively by the Standard Oil Co. of California for all types of heating applications.

Let us help you with your problems in all standard and specialty heating work. Forster Burners have been exhaustively tested under all firing conditions; their combustion is equally efficient under high or low firing. Engineers are amazed at their rugged performance and fuel savings of 10% to 40%.

Forster Burners are adaptable to all natural, manufactured and liquefied gases for *any* heat application. With burner head combustion, the flame holds fast at any pressure.

Sales Opportunities For Dealers and Agents
Write for details and descriptive literature.

REPRESENTATIVES: Oakland, Calif., Forster Sales & Service Co., 309 13th St. **San Francisco, Calif.,** Standard Oil Co. of Calif. **Des Moines, Iowa,** Forster Sales Co., 3312 8th St. **Kansas City, Mo.,** Skelgas Co., 2534 Madison St. **Portland, Me.,** The Utilities Distributors, Inc. **Hammonton, N. J.,** Natural Gas Co. of N. J. **Cherryville, N. C.,** Rulane Gas Co. **Cape Town, South Africa,** South African Liquid Gas Co., Ltd.

FORSTER MFG. CO., LTD., 1852 Alcatraz Ave., Berkeley, Calif.

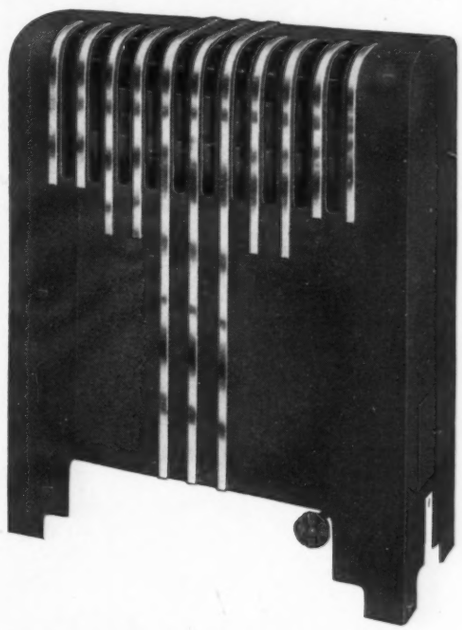
FORSTER HIGH EFFICIENCY GAS BURNERS

FAR *from* ORDINARY
• • • • *except in price*

The NEW NO. 30-C HUMPHREY CIRCULATOR

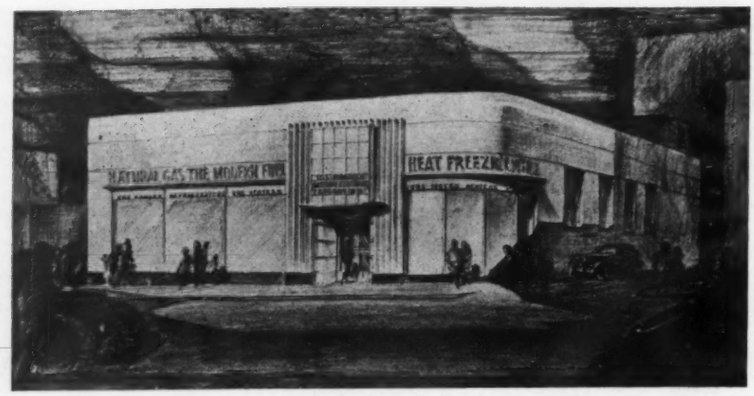
This brilliant new gas Circulator is now ready to help you secure additional gas loads from Homes, Offices, Stores and small Shops. Smart styling and characteristic Humphrey quality construction make this heater an outstanding value and a fast seller.

The No. 30-C Humphrey Circulator has an input rating of 30,000 B. T. U. per hour and is available with or without fan equipment. The price is within the reach of modest budgets. We suggest you write for further interesting particulars.



FINISH: The 30-C Humphrey Circulator is finished in a rich Walnut Brown with sparkling chrome trim.

GENERAL GAS LIGHT CO. KALAMAZOO, MICH.



As the artist visualizes new Hollywood gas office

Los Angeles G. and E. Builds Branch

Construction of the Los Angeles Gas and Electric Corp.'s new $100,000 Hollywood branch office building, located on Ivar street just south of Hollywood Boulevard, was started late last month, according to an announcement by Harry L. Masser, vice president and assistant general manager of the public service company.

Scheduled for completion this fall, the building will be constructed of structural steel and concrete. It will be a basement and single floor building, with provision for a second story at any time in the future. The main floor will house a display room and office staff. A model kitchen and auditorium seating 300 are included in plans for the basement. The new building will have a modern front 60 feet wide with full plate glass windows and will extend to a depth of 150 feet.

■ ■

Union Gas & Electric Merges With Cincinnati G. & E.

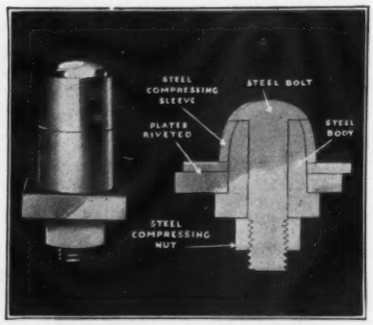
Announcement is made of the merging of the Union Gas & Electric Co., Cincinnati, Ohio, with the Cincinnati Gas & Electric Co., effective last June 30, according to H. C. Blackwell, president of the Cincinnati Co. Prior to that date Union G. & E. had operated gas properties in and about Cincinnati under lease from Cincinnati G. & E. No change has been made in the outstanding securities of the Cincinnati Co., and the organization formerly employed by the Union Co. will continue to operate the property.

■ ■

Steel Body Rivet Useful On Inaccessible Jobs

RIVETING jobs that are not accessible from both sides, can now be accomplished from one side with this new steel Mechanical Rivet manufactured by the Multi-Seal Mfg. Co., Chicago, Ill. This is done by inserting the rivet and drawing down on the nut forming a solid steel rivet head on the inside.

The Steel Mechanical Rivet is made of a one-piece steel body consisting of a heavy steel cylinder with a square head at one end. The other end has a taper valve seat, which



sets in a steel expansion and compressing ferule. A steel bolt goes thru the center with its head under the steel compressing ferrule and the nut at the other end which compresses and expands the steel ferrule when turned down.

The product is used for riveting steel girders, sheet metal of all kinds, machinery, boiler seams, metal castings, plates on metal containers, pipes and various manufactured products, and is of importance to steel construction, railroads, steamship lines, tunnel construction, outdoor sign companies etc. The rivets are used for maintenance work to fasten plates on cracks or holes in fire boxes as they are not affected by heat or pressure. They are useful in replacing loose rivets.

■ ■

Geo. Hobbs, Ruud Executive, Is Accident Victim

DEATH due to accident came on June 18th to George Hobbs, manager of the Toronto, Ontario factory of the Ruud Manufacturing Co., and a Canadian pioneer in the manufacture and sale of automatic gas water heaters.

Joining the Ruud Manufacturing Company in the spring of 1907, he returned to Canada, where he established a selling organization for Ruud Automatic Gas Water Heaters and later the factory which he managed successfully until his untimely death.

Mr. Hobbs is survived by two sons, Harry E. Hobbs, George E. Hobbs, a daughter, Mrs. A. W. Wilkinson and by two brothers and sisters. He was an outstanding leader in the development of the popularity of automatic gas water heating in Canada, and respected by all who knew him.

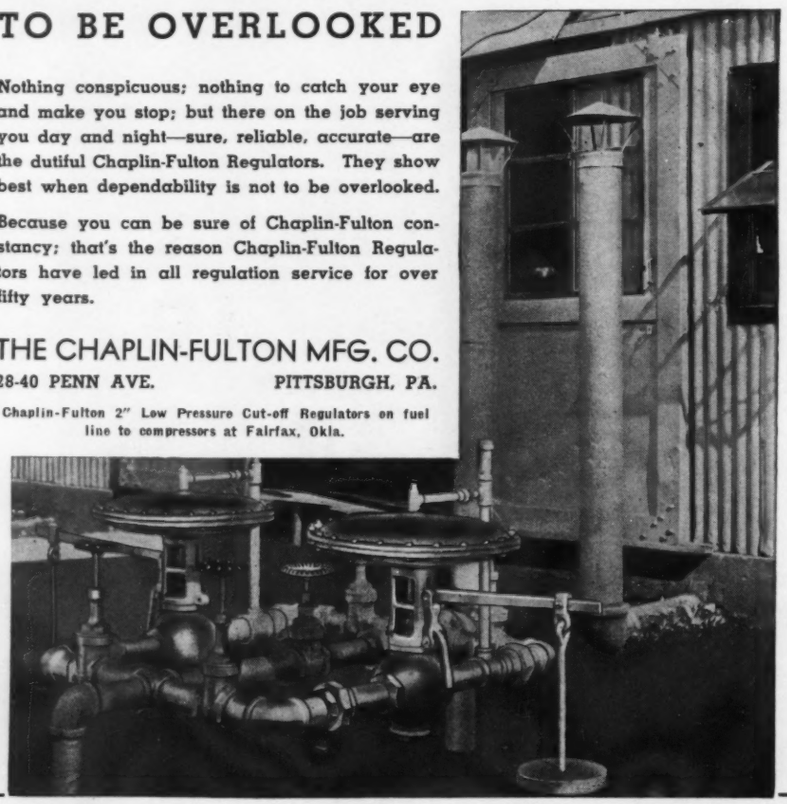
WHERE DEPENDABILITY IS NOT TO BE OVERLOOKED

Nothing conspicuous; nothing to catch your eye and make you stop; but there on the job serving you day and night—sure, reliable, accurate—are the dutiful Chaplin-Fulton Regulators. They show best when dependability is not to be overlooked.

Because you can be sure of Chaplin-Fulton constancy; that's the reason Chaplin-Fulton Regulators have led in all regulation service for over fifty years.

THE CHAPLIN-FULTON MFG. CO.
28-40 PENN AVE. PITTSBURGH, PA.

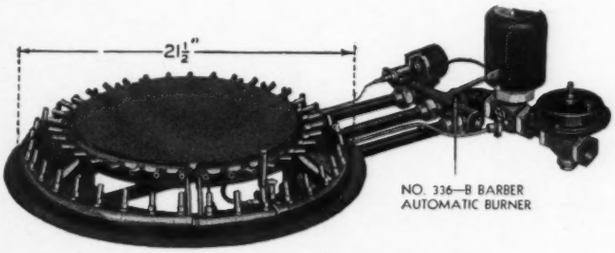
Chaplin-Fulton 2" Low Pressure Cut-off Regulators on fuel line to compressors at Fairfax, Okla.



You'll Want This NEW BARBER Gas BURNER Catalog

BARBER Burner Illustrated Catalog No. 37 is just off the press. It is an authoritative guide to the BEST in modern Gas Conversion Burner design for any make, size, or shape furnace or boiler. It shows 36 NEW models in Barber Burner Units. It includes the complete line of Barber Burners for numerous Gas-Burning Appliances **outside** the house-heating field. It contains valuable engineering data on specifications, capacities, etc., also full information on automatic controls (including all-gas controls.) You will find this Book of genuine assistance in your Gas Heating and Appliance problems. Ask for YOUR copy, with prices and discounts.

BARBER Automatic Jet Gas Burners and Barber Gas Pressure Regulators are listed in the A.G.A. Directory of Approved Appliances. The confidence which both Gas Companies and the Heating Trade have placed in Barber Products, for more than 18 years, should convince YOU that it PAYS to tie up with Barber.



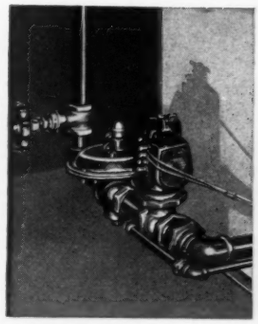
THE BARBER GAS BURNER CO.
3704 Superior Ave. Cleveland, Ohio

THE BARBER GAS BURNER COMPANY OF MICHIGAN
4475 Cass Ave., Detroit, Mich.

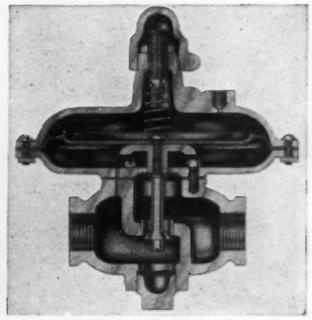
BARBER *Automatic* JET GAS BURNERS

● **for Warm Air Furnaces, Steam and Hot Water Boilers** ●
and Numerous Other Heating Appliances

STEADY!



Actual installation of Reynolds Furnace Regulator.



Cross-sectional view of New Reynolds Refrigeration Regulator. *Note* simplicity of construction, ruggedness and fool-proof design.

● **REYNOLDS Low Pressure Regulators guarantee steady, constant, unvarying pressure, even though the volume varies and line pressure fluctuates. Precision built and delicately balanced for accurate performance on low pressure installations, the units shown above are backed by the factory test through a range of operating conditions . . . but the thousands in operation after years of service is the proof that Reynolds Low Pressure Regulators are reliable, economical and safe. Our Engineering Department is at your service.**

REYNOLDS PRODUCTS

High Pressure Service House Regulators—Straight Lever Type—Models 0-10-20 series; Toggle Lever Type—Model 30 series.

Low Pressure Service or Appliance Regulators.

District Station Regulators Single or Double Valve—Auxiliary Bowl and Automatic Loading Device Optional.

High Pressure Line Regulators—Pilot Loaded—Pilot Controlled.

Toggle Type Regulators—Single Valve, Double Valve, Triple Outlet.

Seals—Dead Weight or Mercury. Back Pressure Valves . Automatic Quick Closing Anti-Vacuum Valves . Automatic Shut Off Valves . Lever Operated Valves . Louver Operated Device . Atmospheric Regulators . Vacuum Regulators.

☆

Branch Offices:
421 Dwight Building
Kansas City, Mo.
2nd Unit,
Santa Fe Bldg.
Dallas, Texas

Representatives:
Eastern Appliance Co.
Boston, Mass.
F. E. Newberry,
Avon, N. J.

REYNOLDS GAS REGULATOR CO.
ANDERSON, INDIANA, U. S. A.

GAS CONTROL SINCE 1892

When Convention Days Are Over

COME TO SANTA CRUZ

Pasatiempo is only one of three inviting golf courses at your disposal . . . . or you may swim, ride, motor or spend your time on delightful Santa Cruz Beach. Plan now for your trip to the San Francisco Convention to include a visit here.

Santa Cruz—Home of the General Offices of

Coast Counties Gas and Electric Company

Machine Coated

The illustration above shows pipe, machine coated and wrapped with NO-OX-ID and NO-OX-ID-IZED Wrapper, in the yard of the Pipe Line Service Corporation of Maywood, Illinois. This economical method of application, to which Dearborn Engineers have contributed greatly, adds another reason for using these materials. Standardizing on NO-OX-ID means a minimum of maintenance in years to come. Inquiries invited.

DEARBORN CHEMICAL COMPANY

Los Angeles: 807 Mateo Street Phone TRinity 3385

San Francisco: 421 Bryant Street Phone SUtter 8688

The NO-OX-ID MASTER COAT

INLAND
GAS SPECIALTIES
Make Satisfied CUSTOMERS

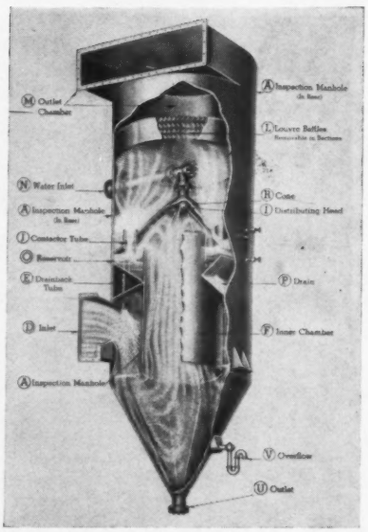
Unit-heater and gas burner sales go up . . . maintenance and service costs go down . . . and customers STAY satisfied when you specify Inland Gas Specialties on every installation. Send for illustrated folder describing our: Unit Heater Hanger and Canopy, Gas Cock Switch; Adjustable External Lighter; Safety Gas Cock; and Furnace Door Closer.

New Pacific Distributor

Harry V. Payne, 3834 3rd Avenue, Los Angeles, California, has recently been made distributor of Inland Products. He will gladly give you full details, and will arrange a demonstration at your convenience. Or you may write direct to us for any information you desire.

INLAND GAS SPECIALTIES

INLAND MANUFACTURING COMPANY
(Dept. 2) 1120 North Cicero Ave., Chicago, Illinois



New Gas Washer Announced By Blaw-Knox Co.

THE Blaw-Knox Co., Pittsburgh, Pa., announces to the industry a "Combined Cyclone-Gas Washer", which is a cyclone combined with the Blaw-Knox patented principle of gas washing. With reference to the illustration above, a description of the operation of the unit as follows.

The dust-laden air enters the unit through the inlet connection (D) where it meets the liquid flowing down the sides of the cyclone shell from drainback tubes (E). The high entrance velocity together with the centrifugal action imparted to the dusty air causes it to wipe the water over the inside surface, thereby forming a film to receive the particles of dust impinged against the sides of the cyclone and effecting primary separation of the dust.

The lighter and finer particles of dust remaining in the air stream pass up through the inner chamber (F) to the under side of the cone (R), where it is deflected downward towards the liquid surface in the reservoir (O). The dust laden air passing at high velocity between the bottom of the contactor tubes (J) and the liquid surface sweeps the liquid with itself upward through the tubes. Within the tubes the liquid is atomized into a very fine spray by the action of the gas while the particles of dust are caused to converge into a central core at the same point into which the liquid is being swept. The combined action results in an intimate mixture of liquid and dust particles whereby the dust becomes wetted and the particles attached to drops of liquid. The mass of air and finely divided spray issues from the contactor tubes into the space above where separation begins with the liquid droplets falling back on the upper surface of the cone (R). Some of the liquid entrained at the entrance of the contactor tube is thrown against the sides of the tubes and tends to run down the inside tube surface. This liquid forms a curtain which is forcibly whipped off the lower edge by the inrushing air stream and carried upward into the tubes.

After passing through the contactor tubes, the washed gas stream expanded in the space above is forced through the louvre baffles

(L) which effect the final separation of any moisture left in the gas stream. The cleaned gas is then exhausted through the outlet chamber and passage (M).

The water or the washing liquid enters the unit at the connection (N) and passes on to the center of the unit, through the distributing head and pipes (I) into the reservoir (O). A gauge glass on the exterior of the unit indicates the level of the fluid in the reservoir at all times. Arrows show the lever at which the liquid is to be kept in the reservoir.

After being carried upward from the reservoir through the contactor tubes, the liquid drains from the upper surface of the cone (R) through drainback tubes (E) into the cyclone section where it is used to wet the interior walls.

Provision is made to flush out any dust that might accumulate in reservoir (O). The liquid supply lines from the distributing head are extended down to the bottom of the chamber and bent at the ends to give the discharged liquid a swirling motion. All sediment in the swirling water is flushed out through drain opening (P) and thence through an opening in the bottom cone to the collecting hopper.

The liquid settling in the collecting hopper passes out through outlet (U).

To prevent the liquid level from rising too high in the collecting hopper, an emergency overflow is provided at (V). This outlet is equipped with a trap to seal against the suction within the unit.

Three inspection manholes (A) are provided in the shell, one adjacent to the inlet (D), another just above the contactor tubes (J) and the third above the louvre baffles or separator.

■ ■

McIntyre Resigns as Manager of Texas Utility

W. A. McIntyre, manager of the Peoples Gas Co., Port Arthur, Texas, has severed his 10-year affiliation with the company, and will be succeeded in office by John H. Pritchard of Bluefield, West Virginia. Mr. McIntyre has made no definite announcement of his future plans. Starting with the company as a salesman, Mr. McIntyre was promoted to Sales Manager, and a few years ago was made manager of the company.

■ ■

Phillips Rejoins Worthington

William H. Phillips, recently with Harry Pratt Co. of Chicago, has joined the Worthington Pump and Machinery Corp. as power plant specialist with headquarters at the corporation's Chicago Office.

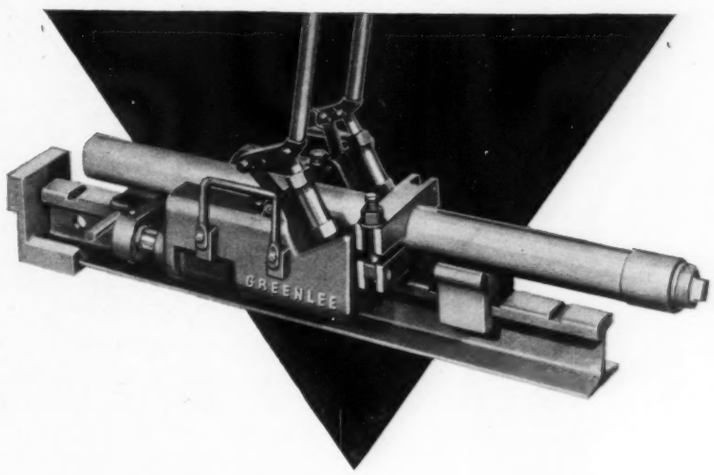
Mr. Phillips was formerly for many years with the Worthington Pump and Machinery Corp. He will specialize on condensers, steam-air ejectors, feedwater heaters and boiler feed pumps.

■ ■

Gas Light Fixtures Displayed

Displayed last month in the window of the Baraboo office of the Wisconsin Power & Light Co. of Milwaukee were gas light fixtures made for the Al Ringling theater by the Baraboo Gray Iron Foundry. The gas fixtures are a replica of the electrical fixtures in use in the theater and are to be used as emergency lights at the exits.

Push Pipe the Easy Way



Greenlee Hydraulic Pipe Pusher

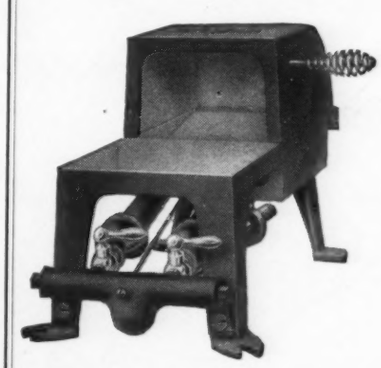
Much time and labor can be saved by using the Greenlee Hydraulic Pipe Pusher, as compared to trenching or using a pusher that requires so much man power to operate it. With the Greenlee, one man can stand in a comfortable position and exert a pressure of 40,000 pounds on the pipe clamp. Eight speeds are provided for varying soil conditions.

The Greenlee Pusher is self-contained. It operates on a notched steel base, which can be furnished in various lengths. After forcing the pipe forward 4 inches, the handles are depressed to release the pressure while springs within the body quickly bring the pistons up to a new notch. This operation is repeated until the end of the base is reached, when the machine is pushed to the opposite end and the pipe clamp reset. This means that pipe clamps are changed only every 4 to 7 feet, depending on the length of rail used.

It will pay you to investigate this improved method of making underground installation of pipe, because of the savings that can be made. A letter or postcard will bring complete information. No obligation on your part, of course.

Write Now for Complete Details

GREENLEE TOOL CO., 1700 Columbia Ave., ROCKFORD, ILL.



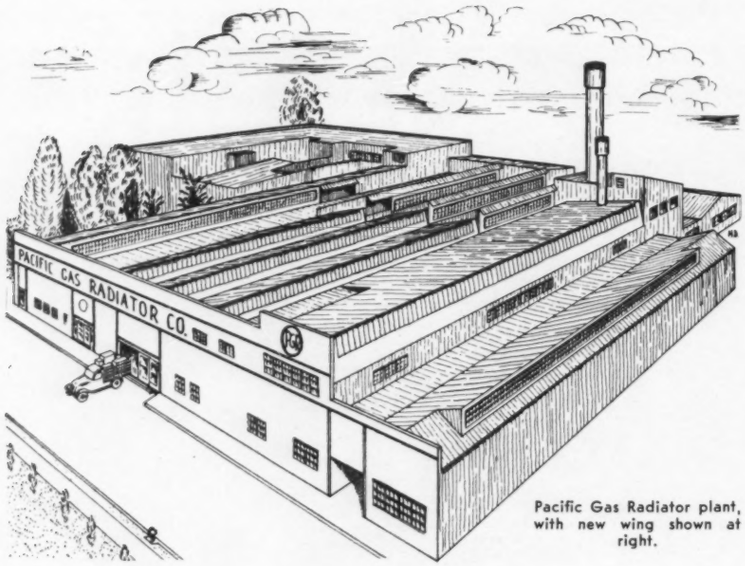
JOHNSON NO. 502 SOLDERING FURNACE

A compact, powerful, efficient and economical soldering furnace especially designed to heat coppers up to 10 to 12 lbs. per pair. No forced air blast required. Equipped with two powerful Johnson Bunsen Burners, each with shutoff valve and pilot light. Johnson patented curved-top, return-blast hood is hinged. Can be tilted back or easily removed. Free catalog sent on request.

JOHNSON GAS APPLIANCE CO.
Cedar Rapids IOWA

Western Representative:
C. B. BABCOCK CO.
135 Bluxome Street
San Francisco, Calif.

Eastern Representative:
J. H. McPHERSON
250 Stuart Street
Boston, Mass.



Pacific Gas Radiator plant, with new wing shown at right.

Pacific Gas Radiator Adds to Plant

PACIFIC Gas Radiator Co., Huntington Park, Calif., is currently completing a new addition to its block-long plant, according to an announcement by A. J. Hartfield, president of the company. The new building, 45 feet wide by 220 feet long, has a total floor space of 86,122 square feet. Included in the new construction are a modern machine shop, plating department, brass foundry, and a larger water heater department.

New show rooms, displaying a complete line of all gas heating and air-conditioning appliances made by the company, have just been finished. Offices have been remodeled and will be air-conditioned throughout by means of a new Pacific air-conditioner.

Organized in 1913, the company started by manufacturing furnaces in a small, one-unit building. Today the large plant produces warm air circulators, modern Thermolators, radiant heaters, gas steam radiators, gas-fired floor and basement furnaces, forced air units, water heaters, and air-conditioning units. Products are sold in nearly every state in the Union and in many foreign countries.

■ ■

So. Calif. Companies Offer "Summer Heating Plan"

A SPECIAL "Summer Heating Plan," in effect from July 1 to August 31, currently sponsored by the Los Angeles Gas & Electric Corp., the Southern California Gas Co., and the Southern Counties Gas Co., is offering to Southern California property owners built-in gas heating equipment at a 10 per cent discount. The campaign excludes sales on new construction.

Coincident with the campaign the Bank of America is extending terms under Title I of the National Housing Act, under which (1) central or unit furnaces and floor furnaces and (2) gas fired boilers and steam heating systems for residences, apartment houses or commercial buildings may be purchased. Under the revised regulations of the Federal Housing Administration, circulators, console type heaters and other portable or removable types of equipment are not eligible for such financing. Bank of America terms offer no down payment, 36 months to pay, $3.00 minimum monthly payments, no carrying charges until September with the first payment falling due in October.

Throughout the campaign the gas companies will jointly advertise the plan in 200 daily and weekly Southern California newspapers. Manufacturers and distributors have been contacted by the companies and urged to tie-in with the campaign. One purpose of the extensive advertising campaign is to bring to the attention of the public the fact that Title I loans are still available for gas heating equipment qualifying under the revised regulations of the F. H. A.

■ ■

Texas Chain Stores Win Tax Victory

CHAIN stores of Texas won a victory, July 3, in their attack on the validity of the state chain store tax, when Judge Royall R. Watkins of Ninety-fifth District Court, Dallas, perpetuated injunctions granted last January preventing the state from collecting the tax.

Judge Watkins' decision came at the close of two days of arguments, following a three-week trial of the suit, which involves $1,000,000 a year in taxes which the chains would have been required to pay had the law been upheld.

The decision ended the first round of a fight which is expected to be carried to the Supreme Court, as both the chains and the state have made it plain that they intend to carry the case as high as possible.

Due to the chain store tax several Texas utilities have reduced the number of their offices merchandising appliances. If the tax is proved unconstitutional, the way will be reopened for normal utility merchandising.

Gas gets the inside track in

House Heating

with the new

Dual

Watrola

Combines space and water heating in one compact, economical gas unit.

Heats for Half

...P. C. G. A....

Delegates are invited to special demonstrations at the factory during the convention.

Watrola Corporation, Ltd.

1170 Howard St., San Francisco

316 So. San Pedro St., Los Angeles

SPACE HEATING WATERHEATING AIR CONDITIONING

PERFORMANCE *measures the value of* BLAW-KNOX GAS CLEANERS

Reduction of Customer Complaints due to dust picked up by gas

"Availability" of Compressors during Peak Loads

Freedom from Dust Deposits on Compressor Valves

Lower Pump Station Upkeep Costs

Fourteen repeat orders from a large transmission system, totaling twenty-six units—indicate a definite confidence in the ability of Blaw-Knox Gas Cleaners to eliminate dust troubles, to reduce maintenance costs, and to maintain public relations.

This large transmission system (name on request) has invested in Blaw-Knox Gas Cleaners as follows:

Number of orders—14
Total number of units—26
First purchase—August 22nd, 1930
Last purchase—August 19th, 1935
Maximum working pressure—450# Ga.
Combined capacity—31,595,000 cf. hr. at 150# Ga. or
59,823,000 cf. hr. at 350# Ga.

This record of purchases indicates satisfaction with results from the equipment and an appreciation of the importance of the *protection* and *transportation cost reduction* afforded by Blaw-Knox Gas Cleaners.

Blaw-Knox Gas Cleaners are fully engineered, reliable and efficient, backed by a manufacturer who accepts the responsibility for meeting your conditions and fulfilling all performance claims. Full information about Blaw-Knox Gas Cleaners, large or small, is yours for the asking.

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2033 FARMERS BANK BUILDING - PITTSBURGH, PA.
Offices in Principal Cities

Your Customers Can Now

ENJOY BOTH

at an Amazingly LOW COST

Small homes, as well as large homes, can now have modern heating and air conditioning. The new Pacific Forced Air Unit (right) supplies fresh, pure, filtered air—WARM in Winter—COOL in Summer! Easily installed in kitchen, closet or screened porch NO BASEMENT REQUIRED. Can be placed anywhere

Ask for Model A-11

◀ Winter HEATING!
◀ Summer COOLING!

"Absolutely wonderful", "more than I expected" . that's what users are saying about this new PACIFIC FORCED AIR UNIT. In summer, it fills your rooms with a gentle, circulating breeze that *drives out the heat!* In Winter, it maintains constant, uniform warmth everywhere! It's noiseless, fully automatic, efficient and economical Get all the facts NOW! Don't wait!

Ask for Folder No. WG-8

PACIFIC *Forced Air Unit*

PACIFIC GAS RADIATOR COMPANY
Huntington Park, Calif. U. S. A.

For ADDITIONAL LOAD This Winter

Campaign with

GLO★FIRE

A CIRCULATING HEATER

It has won instant acclaim wherever shown to the Gas Industry! It converts the long neglected fireplace into a thing of beauty and a NEW LOAD BUILDER!

Watch sales resistance tumble when you show them GLO-FIRE Gas Logs because they are:

- Odorless
- Realistic
- Economical
- A.G.A. Approved

Order now to Insure Early Fall Delivery

★

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3350-56 WEST FIRST STREET

LOS ANGELES, CALIFORNIA

Left to Right: Professor Alfred H. White, University of Michigan; Fred Batten, most recent holder of Michigan Gas Association's fellowship; Herman Russell, first holder of fellowship.

Michigan Gas Ass'n. Elects Officers

MEETING at Mackinac Island, Mich., on July 6-8, in joint convention with the Michigan Electric Light Association, Michigan Gas Association elected N. E. Loomis president for the coming year. Mr. Loomis is merchandise sales manager of the Detroit City Gas Co. Howard Pett, division manager of the Consumers Power Co., Lansing, was elected vice-president. Albert G. Schroeder, secretary of the Grand Rapids Gas Light Co., was re-elected secretary-treasurer.

Michigan Gas Association in the year 1900 established a gas fellowship at the University of Michigan, under the direction of Professor Alfred H. White, then a young instructor in the Department of Chemical Engineering. For the past 36 years Professor White, who is now head of the University's Chemical Engineering Department, has directed this fellowship, which has contributed many engineers to the gas industry. At last month's convention the first holder of the fellowship, Herman Russell, now president of the Rochester Gas and Electric Corp. and vice-president of the A.G.A., and Fred Batten of Detroit, the most recent holder of the fellowship, were photographed together with Professor White, as shown in the picture above.

P. C. G. A. Sponsors Novel Contest

A CONTEST to determine "Who Are The Gas Appliance Manufacturers?" was sponsored by the Pacific Coast Gas Association last month and created much interest among gas employees of member companies. Aim of the contest was to name the manufacturers of 27 gas appliances pictured without identifying trade marks on the contest folder. All appliances illustrated are manufactured or sold by company members of the Association. The contest is being carried on through the P.C.G.A. Educational Committee, of which Eugene G. McCann of the Pacific Gas and Electric Co. is chairman.

Thirty-nine prizes ranging from $5 to $50 and totaling $300 will be distributed for the best entries submitted. In addition some member companies are offering extra prizes to employees who turn in winning papers.

Entries are judged on a basis of 54 per cent grade value for correct identification of appliances, 16 per cent for a five or six word gas industry slogan, and 30 per cent for a 25-word essay "Gas Fuel Is Best For Cooking, Water Heating, Refrigeration, and House Heating, because . . . . . ."

Those named on the final judging committee are: K. C. Tomlinson of the American Meter Co., James Knollin of Gerth-Knollin Advertising Agency, and Irving F. Harris of Redlick Newman Furniture Co.

Contest directors who will handle the contest in their respective companies and turn the winning papers over to those on the final judging committee, are as follows:

M. H. Saunders, Central Arizona Light and Power Co.; J. E. Wolfe, Coast Counties Gas and Electric Co.; W. C. F. West, Los Angeles Gas and Electric Corp.; O. B. Custer, Northwest Cities Gas Co.; A. J. Noia, Pacific Gas and Electric Co.; L. H. Steele, Seattle Gas Co.; H. T. Brian, Southern California Gas Co.; G. W. Wadsworth, Southern Counties Gas Co.; T. R. Hoag, Spokane Gas and Fuel Co.; E. J. Ludeman, Washington Gas and Electric Co.

Pacific Gas and Electric Co. employees are doubly interested in the contest since the company is offering $295 in extra prizes to the winners within the company. The P. G. and E. prizes range from $2.50 to $40.

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Utility Moves Offices

The accounting and bookkeeping offices of the Wisconsin Southern Gas Co., Burlington, Wisc. and the Wisconsin Central Utilities Corp. have been moved from Savanna, Ill. to the Burlington office of the Wisconsin Southern Gas Co. Both companies are subsidiaries of the American Utilities Service Corp., New York City.

TOUGH, ductile and stubbornly resistant to impact, U. S. Super-de Lavaud Cast Iron Pipe, *centrifugally cast in a metal mold without chill,* is available with bell-and-spigot, flexible or mechanical joints for water, gas and sewerage service; with threaded ends in steel o. d. sizes for waste, vent and drainage service; and with the standard Ni-Resist alloy, approximating 14% nickel, 6% copper and 2% chromium, for oil refineries, process industries, mining operations, or wherever super-corrosives are used or encountered. Our laboratories and technicians are continually at work to the end that our service to public utilities and industry shall be improved and extended.

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U. S. Pit Cast Pipe U. S. Threaded Cast Iron Pipe U. S. Mechanical Joint Pipe
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Cast iron and alloy cast iron pipe centrifugally or pit cast—for water works, gas, sewerage and drainage service as well as industrial uses involving corrosives.

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